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OBSERVATIONS OF SURFACE EFFECT VEHICLE PERFORMANCE

Cold Regions Research and Engineering Laboratory

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R.A. Liston

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CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
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13. ABSTRACT

A series of tests conducted in the vicinity of Houghton, Michigan, utilizing the SK-5 surface effect vehicle are discussed. The tests represent a continuation of an earlier study to investigate the interaction between surface effect vehicle and arctic terrain. The following tests were conducted and are reported on: evaluation of air cushion vehicle operations on railroad beds and on secondary roads; the identification of maneuver requirements as a function of vehicle characteristics; evaluation of air cushion vehicle operations on inland waterways; measurement of water speed, craft weight, and skirt drag; and analysis of dynamic response to geometric obstacles.

14. KEY WORDS

Air cushion vehicles
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PREFACE

This report was prepared by Ronald A. Liston, Research Mechanical Engineer, Applied Research Branch (Albert F. Wuori, Chief), Experimental Engineering Division (Kenneth A. Linell, Chief), U.S. Army Cold Regions Research and Engineering Laboratory (USA CRREL).

The work was done in support of the Advanced Research Projects Agency (ARPA) Arctic Surface Effect Vehicle Program under ARPA Order No. 1615, Program Code No. ON10.

The report describes some work contributing to the vehicle/terrain interface study which was done in the spring and summer of 1971. All of the tests reported on were done in and around the Keweenaw Peninsula of Michigan's Upper Peninsula.

The tests were conducted by William Lyons and Jacques Robitaille of the Bell Aerospace Company, Francis Gagnon, Construction Engineering Research Branch, and Ben Hanamoto and R. Liston, Applied Research Branch, Experimental Engineering Division, USA CRREL.

The report was technically reviewed by Gunars Abele, Applied Research Branch, and Ben Hanamoto, both of whom made valuable comments concerning the content and format.

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by

Ronald A. Liston

Introduction

During the winter of 1970-71, USA CRREL conducted a study of a surface effect vehicle (SEV) operating on snow- and ice-covered terrain. The purpose of the study was threefold: to determine operational problems peculiar to arctic environments other than low temperatures; to identify the effect of SEV operations on snow- and ice-covered terrain; and to develop test procedures for this relatively new and unique vehicle form. These studies have been reported upon elsewhere.[1,2]

The study was extended through the spring and summer to investigate the performance of the SEV in water and on organic terrain and to continue developing test techniques. Operation on organic terrain is the subject of a separate report.[3] The only organic terrain tests discussed in this report are those dealing with skirt drag over muskeg.

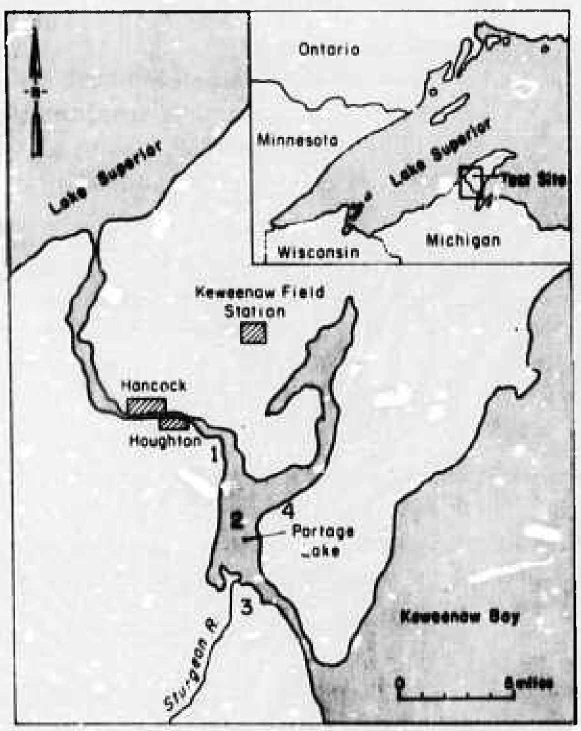

Figure 1. Location of test sites, northern Michigan.

Because of the lack of any relationship between the various tests, each test is discussed as a unit. That is, the objective, procedure and results are presented for one test followed by the objective, procedure and results of the second, etc. The major findings of each test are restated in a single section dealing with the conclusions.

The tests were conducted in and around the Keweenaw Peninsula of Michigan's Upper Peninsula (Fig. 1). This location was selected because of its arctic-like terrain conditions accompanied by a moderate climate and because the U.S. Army Tank-Automotive Command's Keweenaw Field Station located nearby could provide support for the tests.

The vehicle used in the study was the Bell Aerospace Corporation's SK-5. The craft is ideal for this type of study as it is large enough to require a full range of controls and a sophisticated flexible skirt but small enough to be acceptably economical to operate.

Background

Many topics are discussed in this report. Although one or two phases of the study may have warranted separate technical notes, it seemed better to present an anthology, particularly since many of the tests required only a half-day or a day at the most and deserved little more than a paragraph or two. A listing of the topics will indicate the scope of the study:

a. Measurement of drag developed on hard surfaces and over water.
b. Measurement of pitch, roll, yaw, surge and heave while negotiating geometric obstacles.
c. Determination of maneuver path requirements of the SK-5 on natural and artificial courses.
d. Determination of the ability of the craft to operate on roads and railroad beds.
e. Measurement of vehicle weight with engine at idle and with engine not operating.

There is no direct relationship between the effort expended on any particular test, the number of words, graphs and figures used to describe it, and the significance of the results. The reader will be left the task of distinguishing the verbal arm waving from the useful information.

Test vehicle

The SK-5 (Fig. 2) is a military version of the SRN-5 surface effect vehicle produced by the British Hovercraft Corporation. This craft is one of a three-member family: the SRN-4, -5 and -6. The vehicles have a common skirt configuration although the SRN-4 is considerably bigger than the other two. The SRN-5 and SRN-6 are the amphibious SEV's that have been most successful in service throughout the western world. The SK-5 was built in the United States by the Bell Aerospace Corporation under license from the British Hovercraft Corporation. Three craft were built for the U.S. Army and were sent to Vietnam for operational evaluation. Two of them were destroyed in combat. The remaining vehicle was returned to the United States, assigned to CRREL for the Houghton operation and subsequently transferred to the U.S. Army Alaska for an operational evaluation in Alaska.

The gross weight of the craft, including fuel and crew, was approximately 15 000 lb with a cushion pressure of approximately 0.21 psi. When in operation, the vehicle is supported by a cushion of air which is entrapped by an air-filled flexible skirt. The peripheral trunk or skirt has fingers so that on smooth surfaces that do not readily deform there is no contact between the skirt system and the surface.

The air cushion is supplied by a centrifugal fan (Fig. 2). Propulsion is provided by a conventional, variable pitch aircraft propeller. Control is achieved through rudders at the rear of the craft, the variable pitch propeller, a skirt lift system, and puff ports. Blasts of air from the puff ports produce forces that turn the machine about its yaw axis. The puff ports can be used singly or in combination and allow the craft to be pirouetted in either direction or moved sideways by opening both ports on one side.

The skirt lift, not shown in the drawing, consists of a hydraulically actuated chain attached to the bottom of the skirt on one side. When the skirt is lifted cushion air escapes and the craft responds by listing toward the raised skirt. A slight increase in drag results, which aids in turning. The skirt lift is of limited effectiveness and in reality only aids slightly in turning the craft.

Test areas

The majority of the tests were conducted on an area identified as the Isle Royale Sands, Site 1 on Figure 1. The sand is in fact not sand but the tailings from copper mining which are called stamp sand. The material is well graded, with particle sizes ranging from silt to gravel. The area has two useful properties: it is flat so that maneuver courses can be set easily and it is easy to dig

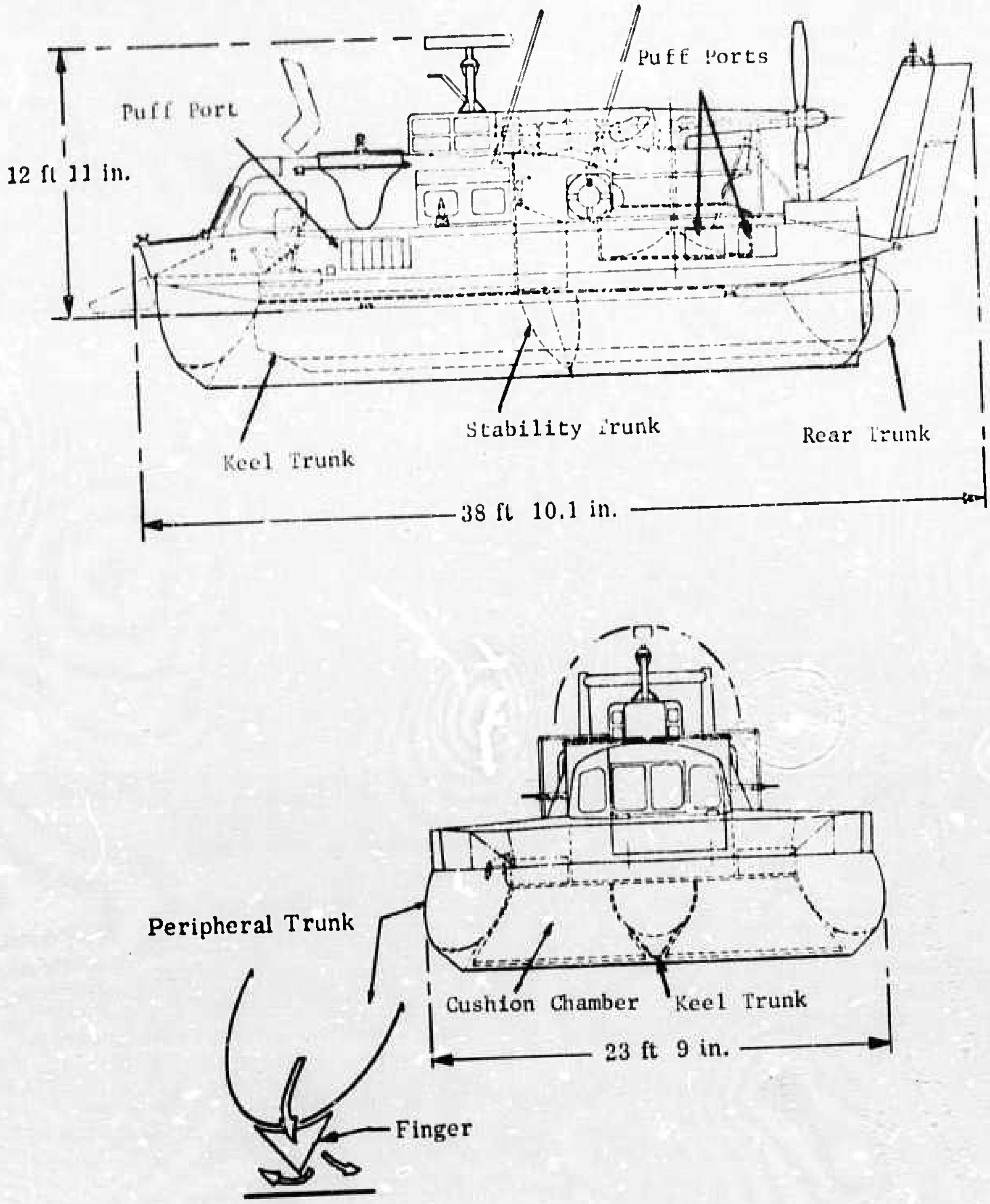

Figure 2. Test vehicle, SK-5 ACV.

into in order to construct obstacle courses. A third characteristic is that the stamp sand will not support the growth of vegetation, giving it little value or appeal. Thus, almost any test activity can be carried on without concern over damage to the environment.

Skirt drag over water and maximum water speed were measured on Portage Lake (Fig. 1, Site 2). Water tests were also conducted on the Sturgeon River, bordering Site 3, to measure maximum speed while operating on a relatively narrow river. The Sturgeon River is crossed by a low bridge approximately two miles from its mouth, which limits its use for operational tests as the narrow portions of the river are not available. However, it was the only river within a 60-mile radius of Houghton that was clear of obstacles and permitted passage of the SK-5.

Skirt drag was measured in Site 3 for several conditions including muskeg, shallow water, grass, and brush-covered grassland. Site 3 suited our purposes nicely as it contains several terrain conditions even though it is small in area. The outer edge has water approximately three feet deep-ideal for shallow water drag tests. Progressing inland muskeg is encountered. The muskeg consists of a mat of live vegetation, 1½ to 3 feet thick, floating in water 2 to 3 feet deep. A layer of peat over a mineral soil base makes up the bottom surface of the muskeg. Further inland the muskeg ends and solid ground is reached. Some of the ground was recently a pasture so there is grass but few bushes or trees. Other areas have accumulated a considerable amount of brush. It was thus possible to measure the drag produced by four distinctly different surfaces.

Site 4 consisted of an unpaved road that was selected because it seemed typical of low traffic density dirt roads in remote areas and was readily accessible from Portage Lake.

Operation on a railroad bed

Objective. The objective of this test was to establish whether limited operation of SEV's on railroad beds is feasible.

Background. In considering the potential of SEV operations in the interior of Alaska, the use of railroad beds as "SEV-ways" was proposed. This appeared to be a good idea until the fact that railroad beds are almost always accompanied by railroad bridges dampened enthusiasm. The railroad bridge is a double obstacle in that the air cushion is lost over the open bridge bottom and the bridge is so narrow that the craft can't squeeze through. Current opinion rejects the general use of rail beds for moving short distances quickly in rough terrain. To be useful, the railroad would have to be devoid of bridges, narrow cuts or fills, which is not a very likely circumstance.

Procedure. The procedure used was as simple as could be imagined. A railroad track was selected that had a bed as favorable to the operation of the SK-5 as could possibly be expected and an attempt was made to operate the craft on the track. The bed (Fig. 3) had a very slight crown and the surrounding surface was sloped to the left at less than three degrees. A small bridge (Fig. 4) was included in the test section to determine the effect of a momentary loss of the air cushion.

Several other sites were selected that were progressively longer and less favorable in order to establish the most difficult conditions that the craft could cope with. Measurements were to include average speed and the geometric cross section of the rail bed.

Results. The craft was totally incapable of remaining on the track while moving forward. As can be seen in Figures 5 and 6, the vehicle oscillated from one side of the track to the other. The operator, although exceptionally capable, was unable to make the machine cope with the combination of the crowned bed and side slope.

The small bridge was a disaster. The craft was completely immobilized by loss of cushion air (Fig. 7). Two four-wheel-drive vehicles were required for recovery, whereas in most circumstances the SK-5 can be recovered by several men pulling on ropes attached to the front or rear.

Figure 3. Railroad bed test site.

Figure 4. Small bridge on railroad bed.

Figure 5. SK-5 sliding to left off tracks.

Figure 6. SK-5 sliding to right off tracks.

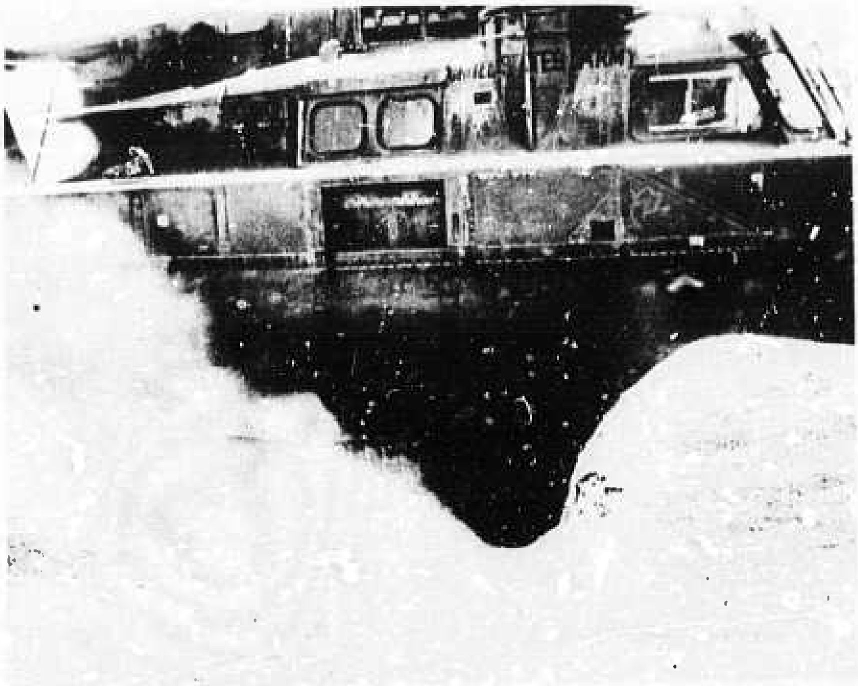

Figure 7. SK-5 immobilized on small bridge due to loss of cushion air.

The short test showed that for all practical purposes SEV's cannot operate on railway beds. It would be possible to attach a guide arrangement to keep the vehicle on the tracks but this would still leave the problems of loss of air cushion and bridges too narrow to permit passage of the craft.

Operation on a secondary road

Objective. The objective of this test was to determine whether operation on secondary roads is feasible.

Background. There is a widespread misconception that SEV's can operate with relative ease on roads. Almost everyone working with these craft has a tale to relate about someone who was not aware of the operational limitations of this type of vehicle. However, there seems to be reason enough to expect a road to offer few problems for a vehicle that is touted as being highly mobile. Off-road vehicles such as tanks operate acceptably well on highways, as do all-terrain vehicles.

In order to investigate the problems of operating an SEV on a road, a simple test was devised.

Procedure. A road (Fig. 8) was selected that appeared to have the normal attributes of a secondary road: slightly crowned, unpaved, ditched on either side, and wide enough to permit two cars to pass comfortably but without wasted space. In addition, a boat landing located on the road made it a simple proposition to get to it from Portage Lake. The road was checked for overhead obstacles and the necessary 16-ft clearance was found for a distance of several miles.

The craft was moved onto the road and timing of speed initiated at the start of the course. The vehicle was to be operated until it became stuck or went a distance of two miles. If the vehicle became immobilized, the cause would be identified and if the vehicle could be extracted by its crew, the test would continue. If the vehicle could not be retrieved by the crew, the test would be considered completed.

Figure 8. Initial immobilization of SK-5 on secondary road.

Results. The craft was in trouble almost as soon as it moved onto the road. The vehicle was set down in the middle of the road prior to the start of the test. At the start, it was lifted onto its cushion and the operator attempted to move along the road, being careful to avoid small trees on the left. The crown quickly caused the craft to slide off the road to the right (Fig. 8). Since no loss of air cushion occurred, it was possible to move the vehicle back onto the road with manpower.

The second serious obstacle encountered by the SK-5 was the combination of a sharp bend in the road and a telephone pole with its associated guy wires. The obstacle (Fig. 9) posed a severe problem for the operator but with a considerable expenditure of energy and time, it was negotiated.

The craft was then moved slowly along the road, but due to the slight crown it slid off the road to the left and into the ditch (Fig. 10). It became immobilized from loss of air cushion and it was not possible to manhandle it back onto the road. The immobilization essentially ended the test because both the crown and the ditch continued for the length of the test section of the road. Continued operation would have consisted of a series of immobilizations occurring so frequently that the craft could only have been considered unable to cope with this terrain condition. It was concluded that the SEV is incapable of negotiating secondary roads.

During the test, the vehicle moved a distance of 530 ft in 6 minutes, 15 seconds for an average speed of 0.96 mph.

The primary reason that the SEV was unable to operate on the road was that it was not possible to compensate for the crown. In order to move along a side slope, which is equivalent to the crown, it is necessary that the craft be put in a crabbed attitude. Few secondary roads are wider than 30 ft. Thus, the crown produces two slopes 12 to 15 ft long. Since the SK-5 is approximately 40 ft long, it was not possible to place it in the proper attitude to remain on the slope and move along the road. Its progress was characterized by constant slithering from one side of the road to the other punctuated by emergency stops to prevent sliding off the road altogether.

Figure 9. Obstacles consisting of 90° turn, telephone poles, and guy wires.

Figure 10. Final immobilization of craft on secondary road.

Establishment of maneuver requirements

Objective. The objective of this test was to establish the path width required to permit unrestricted operation of an SEV.

Background. Of the characteristics of SEV's, there is no question that control of the craft is the most discussed and least understood. This is hardly surprising: people have been flying airplanes for almost 70 years yet many pilots don't fully understand the control behavior of their planes. Compared to a fixed wing aircraft, an SEV is far more difficult to control because it responds to variations of both the ground surface and the surface winds. Although control has been vastly improved by clever engineering design, many people still consider SEV's to be totally uncontrollable. Their thoughts are directed to the development of add-on or retractable wheels to provide positive directional control. The fact that the solution of the alleged control problem might well destroy the effectiveness of the SEV in its intended operating environment is often lost sight of.

At the other end of the scale are those who assume that an SEV is under positive directional control at all times. This group is shocked to learn that it is not possible to travel on the highways with ease.

Even those with reasonable experience with SEV's tend to rely upon conjecture to predict whether a vehicle can or cannot negotiate a given terrain condition. It appeared particularly appropriate to determine the path width required to provide sufficient room to control the SK-5.

Procedure. Two test courses were laid out on the Isle Royale Sands. The courses were identical in shape (Fig. 11) but differed in dimensions, one being roughly twice as large as the other. Patches of white cloth spiked into the ground at 20-ft intervals identified the course to the operator and also served as reference marks for measuring the vehicle's path as it negotiated the course. The purpose of measuring the path was to determine how far the vehicle deviated from the marked course. Knowing the deviation of the vehicle path from the centerline, the minimum course width could then be taken as twice the deviation.

The stamp sand surface was excellent for this test as the surface debris was blown clear by the cushion air, making the path easy to identify. The path was measured from the course centerline markers to the outermost or innermost indication of contact between the skirt and ground.

The conduct of the test was straightforward: the operator was instructed to negotiate the course at as high a speed as he felt he could maintain while keeping "reasonable" contact with the course centerline. Speed in the course was measured by timing between points A and B, B and C, and C and D (Fig. 11). Upon completion of the run, the vehicle was moved off the course and the distance between the center of the course and furthest skirt contact established at 20-ft intervals.

Results. The results of this test are tabulated and shown graphically. Except for one point, the tabulated data (Table I) indicate that maximum deviation from the prescribed path tends to depend more on entry speed than average speed. However, a glance at the course (Fig. 11) shows that the opposite conclusion would likely be reached if the start and end points were reversed. The minimum course width is taken as approximately twice the maximum deviation. To accommodate the worst performance, a course 113 ft wide would be needed which is almost three times the length of the SK-5 (38 ft 10 in.).

Figures 12 and 13 display the courses and the deviation patterns produced by the vehicle. The patterns are similar with all major deviations occurring on the outside of curved paths as would be expected from observing the method used by the pilot to negotiate the course (Fig. 14).

Although a great amount of time could be spent analyzing the patterns produced by the test and relating speeds at various points to deviation, the result would be trivial. All that was learned, and

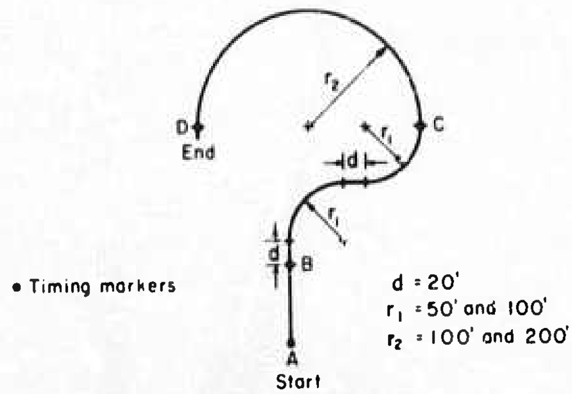

Figure 11. Schematic of maneuver test course.

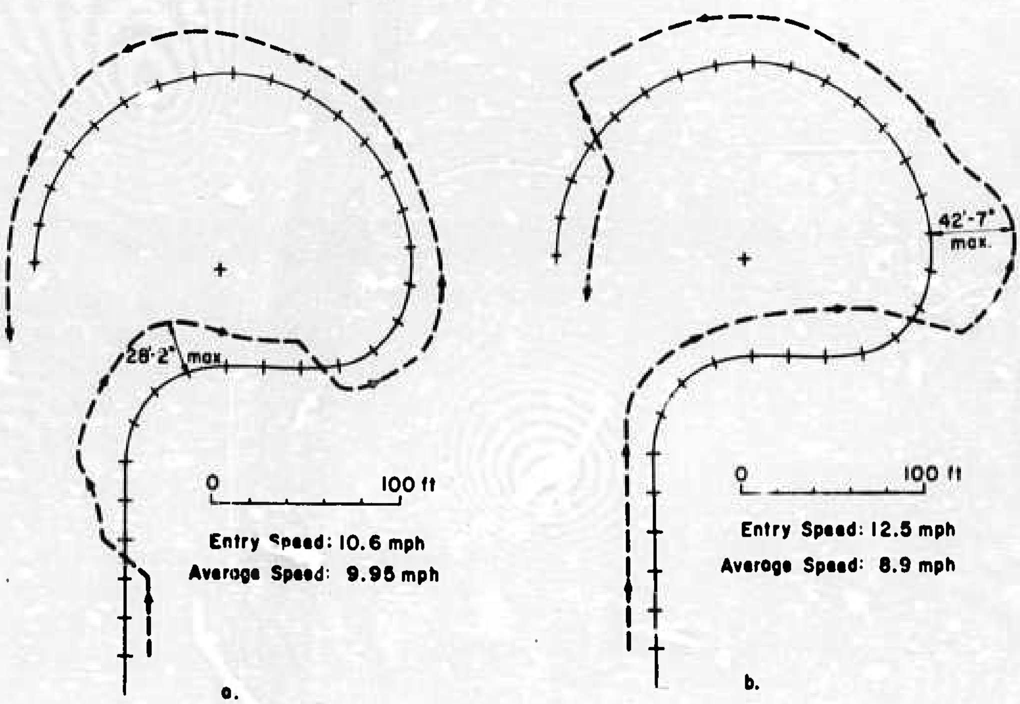

Figure 12. Operations on small maneuver course.

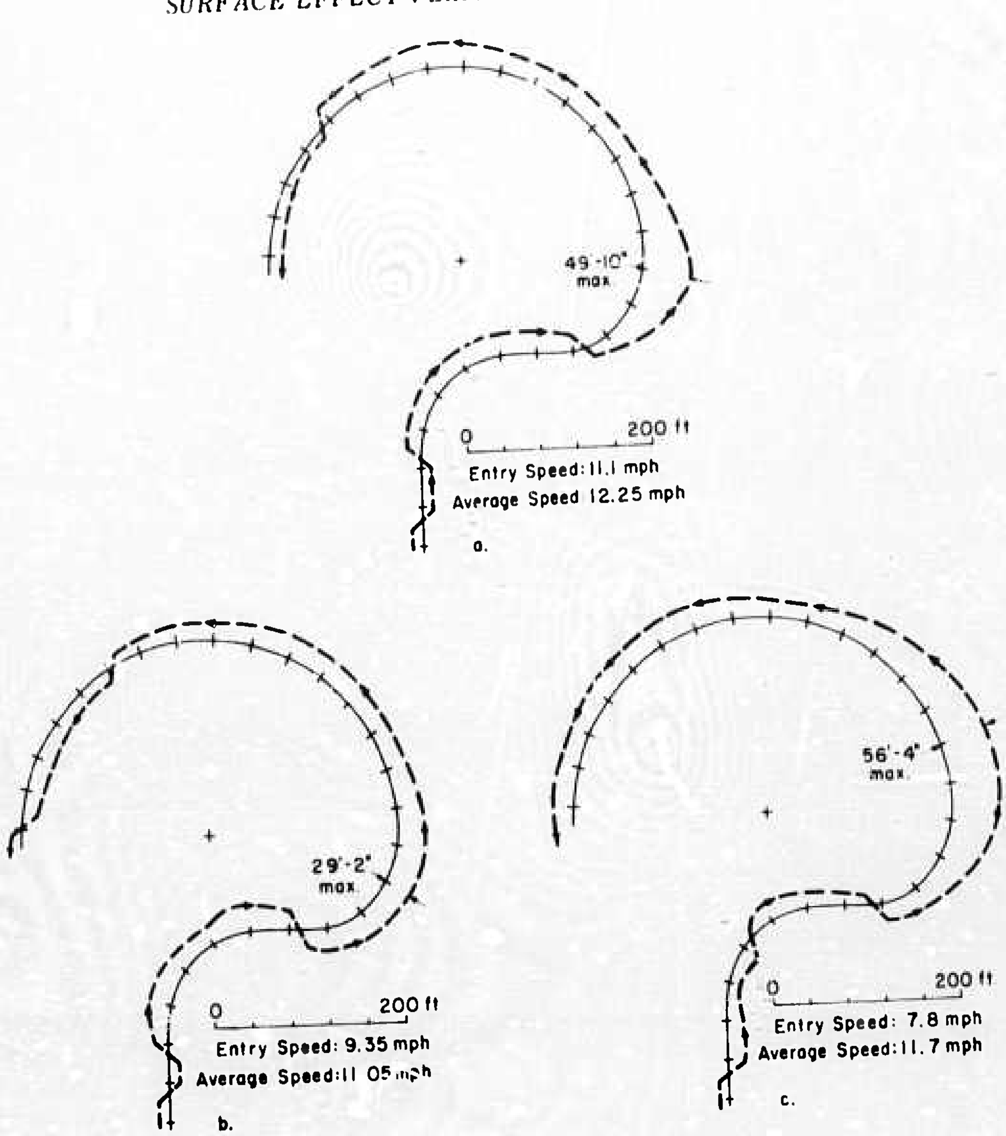

Figure 13. Operations on large maneuver course.

Table I. Data from maneuver test.

Course	*Entry speed, mph*	*Avg speed, mph*	*Max dev*	*Min course width*
Small	10.6	9.95	25 ft 2 in.	56 ft
Small	12.5	8.9	42 ft 7 in.	85 ft
Large	11.1	12.25	49 ft 10 in.	99 ft
Large	9.35	11.05	29 ft 2 in	58 ft
Large	7.8	11.7	56 ft 4 in.	113 ft

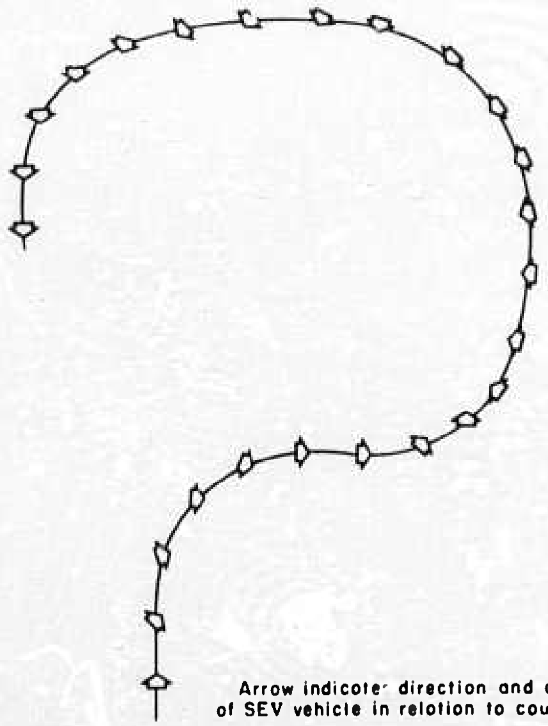

Figure 14. Craft attitudes required for negotiation of maneuver course.

this isn't necessarily insignificant, was that a pathway must have a width approximately three times the length of an SEV if the vehicle is to move along it with ease.

It is obvious that this finding has definite limitations: if the surface on which the SEV is to operate is very rough, the width required will likely increase. On the other hand, if the surface is such that the craft can be stopped quickly, as in water, without fear of damage to craft, crew or cargo, the width required will likely decrease. Also, if the surface has a significant amount of friction, the pilot could reduce the path width required by dragging the skirts, although this is hardly good practice for extended operations.

Operation on inland waterways

Objective. The objective of this test was to evaluate the ability of the SK-5 to operate on a typical inland waterway.

Background. Several factors caused this test to be included in the program, the primary one being the proposed use of SEV's on inland waterways. Since an SEV is capable of operating on water with ease, it is logical that waterways form natural "SEV-ways." If the potential of any given SEV is to be evaluated, it is necessary to identify the types of streams that would support SEV traffic. Additionally, the ability, in terms of speed and maneuverability, of the SEV to operate on the streams needs to be established at the same time. Because of the many rivers in and adjacent to the Keweenaw Peninsula, it appeared appropriate to establish which rivers would support traffic by the SK-5 and to determine its speed capability on each of them.

A secondary factor was to evaluate the conclusions drawn from the results of the maneuver test described in the preceding section. It was hoped that several rivers could be found that would include some with widths more than 120 ft and some with widths less than 120 ft.

Figure 15. Mouth of Sturgeon River.

Procedure. Based on a map study, an aerial survey was made of rivers located on the Keweenaw Peninsula and on Michigan's Upper Peninsula within a 60-mile radius of Houghton. It was surprising to learn that only the Sturgeon River would permit traffic and that even on this river travel would be confined to the first two miles from its mouth. At that point, the river is crossed by a low bridge that is not easily circumvented.

One or both of two conditions prevailed for every other river checked: the river was crossed by a low bridge very close to its mouth or it was clogged with fallen trees, preventing travel by anything larger than a canoe or rowboat. Thus, the only river navigable by an SEV was the Sturgeon River and this could hardly be considered navigable as it was only useful for a two-mile stretch. The mouth of the river is shown in Figure 15. Further up the river, the vegetation at the river's edge changes from marsh grasses to relatively heavy woods. The river is somewhat narrower in spots but the width is not less than two vehicle lengths at any portion of the two miles available for testing.

The test consisted of timed runs up and down the river with the pilot operating the vehicle at the maximum speed he considered safe. The runs were photographed from a light aircraft to record the technique used to negotiate the river at high speed.

Results. It is evident that an SEV can operate with ease on rivers whose width is twice the length of the craft. It is necessary to add several qualifications to that statement, however. First, the river must be deep enough to allow the vehicle to be "dumped" without hitting bottom. For example, in Figures 16 and 17 the SK-5 was not going to be able to negotiate the turn in the river and was headed for the bank in a skid to the left. The pilot dumped the craft by cutting power concurrently with the opening of all puff ports so that he lost lift instantly. The vehicle was stopped in a very short distance, the air cushion reestablished, a new direction taken up, and forward motion resumed all in a few feet and a few seconds as shown by examination of the figures. Because the pilot can regain control very quickly in the event that things get out of hand, he can operate at

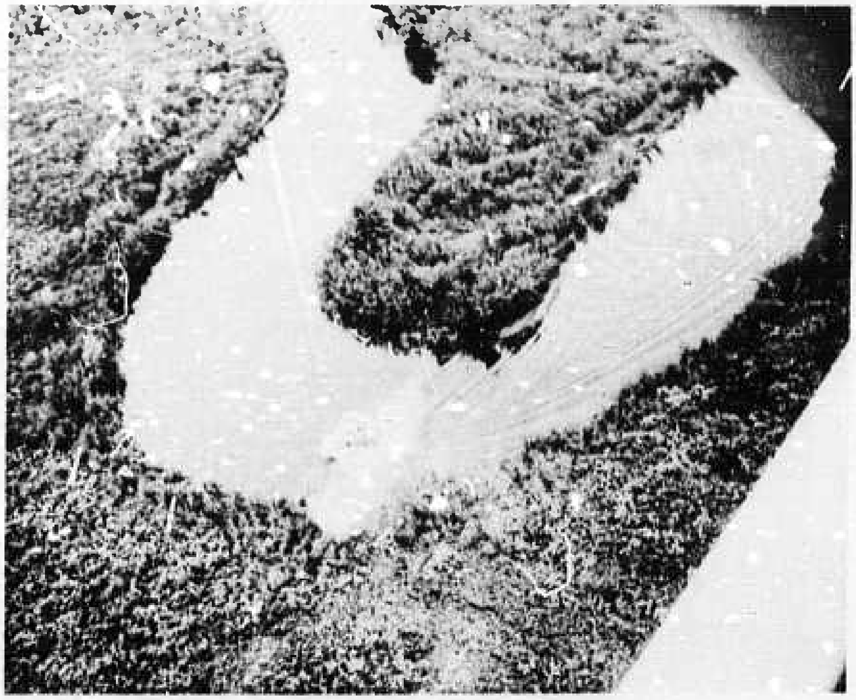

Figure 16. "Dumping" SK-5 in Sturgeon River.

Figure 17. Resuming forward progress on Sturgeon River.

much higher speeds on deep water than on shallow water or on a hard surface. If the river is very shallow with exposed rocks, it is of course necessary to operate as if on a hard surface.

The second qualification is that the river must be free of above-surface obstacles such as bridges or fallen trees. The probability of encountering bridges in undeveloped areas is low, but unless a river is actively used as a waterway the probability of above-surface debris is high. Thus, if a river is to be used for SEV traffic it will have tobe cleared of obstacles.

The third qualification is that first-time operation on almost any river by an SEV would require reconnaissance either by aircraft or by boat. If such a reconnaissance were not made, progress would be exceedingly slow except on straight sections where obstacles could be easily seen.

The method of negotiating the river at high speed was most interesting. In addition to judicious use of the "dumping" technique, the pilot used a system of pre-turning the craft so that he skidded around the turn sideways. A six-photograph sequence (Fig. 18-23) shows the craft negotiating the same turn as in Figures 16 and 17, but in the opposite direction. In this sequence the vehicle can be seen in a combination of the two techniques: skidding (Fig. 18, 19, 20), dumping (Fig. 21, 22) and resuming travel (Fig. 23). The fact that the pilot had to dump the vehicle implies that he lost control of the skid and that the technique was not adequate to negotiate the turn. The implication is correct but the only penalty for the loss of control was a reduction in average speed.

The average speeds achieved by the test pilot were 19.1 mph going up the river and 19.8 mph going down. When the same run was made by a relatively inexperienced pilot the speeds were 17 mph going upstream and 18.7 going downstream. It is assumed that the neophyte learned on his trip upstream so that his downstream speed was quite a bit faster. The test pilot was sufficiently experienced that factors other than learning how to negotiate the river were responsible for the difference in speed.

However, the speeds achieved by the experienced and inexperienced pilots were close enough to indicate that negotiation of the river was quite easy. Subsequent observation by the writer of the SK-5 operating on frozen rivers in Alaska made clear the value of being able to stop quickly. While operating on the Delta River between Fort Greely and Black Rapids, progress was frequently slowed to less than 5 mph in order to ease through fields of stumps and trees lying on top of the ice. The craft required upwards of 50 ft to slide to a stop in order to avoid striking such obstacles. Interestingly enough, however, the long-distance average speed on the Delta River was slightly less than 25 mph. This is accounted for by the fact that speeds on the order of 60 mph were attained on the debris-free areas of ice with ease and full control. It must be recognized that high-speed operation on debris-free areas still requires unimpaired visibility for potential obstacle recognition.

Measurement of water speed

Objective. The objective of this test was to determine the maximum speed over water.

Background. The perversity of the SEV, or at least the SK-5, seems to upset even the simplest of measurements. To measure the maximum speed of almost any vehicle, several runs are made into the wind and several with the wind. The effect of the wind is canceled by averaging the upwind and downwind readings.

This is not practical with an SEV. The runs into the wind can be significantly faster than the runs with the wind. In fact, unless the wind is very strong, the speed into the wind is greater than for calm conditions.

The cause of this seemingly strange behavior is a disturbing maneuver called a "plough-in." A plough-in is precisely what its name implies: the front of the craft buries itself in the water,

Figure 18. SK-5 entering sharp bend on Sturgeon River.

Figure 19. SK-5 skidding around bend.

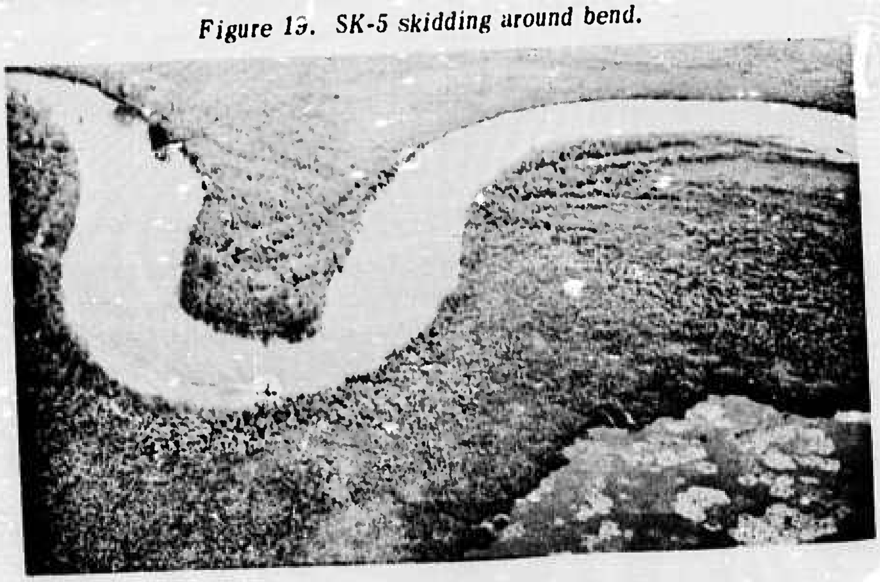

Figure 20. SK-5 still skidding and approaching bank.

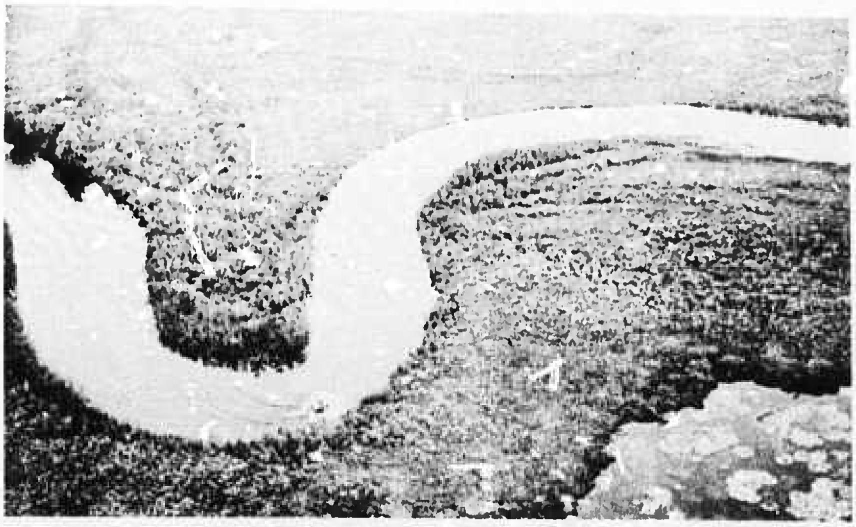

Figure 21. SK-5 pilot initiating "dumping" of craft.

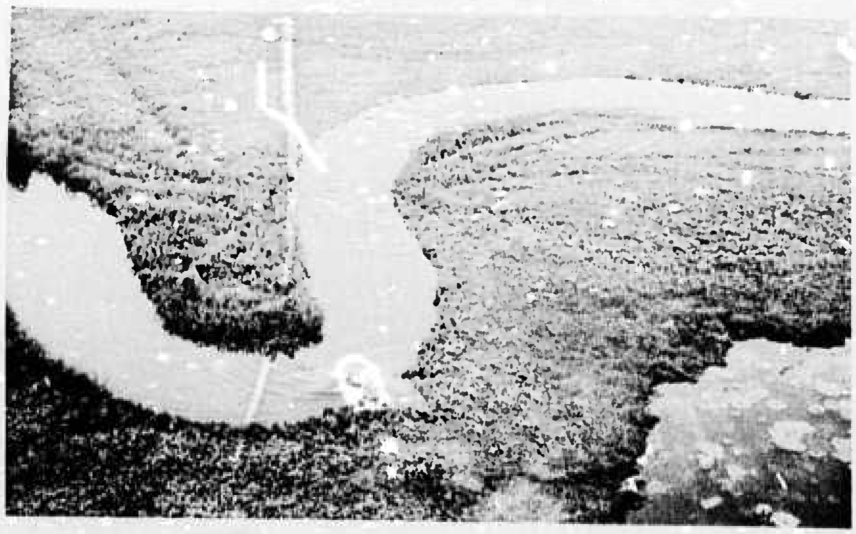

Figure 22. Completion of "dumping".

Figure 23. Continuation of forward progress.

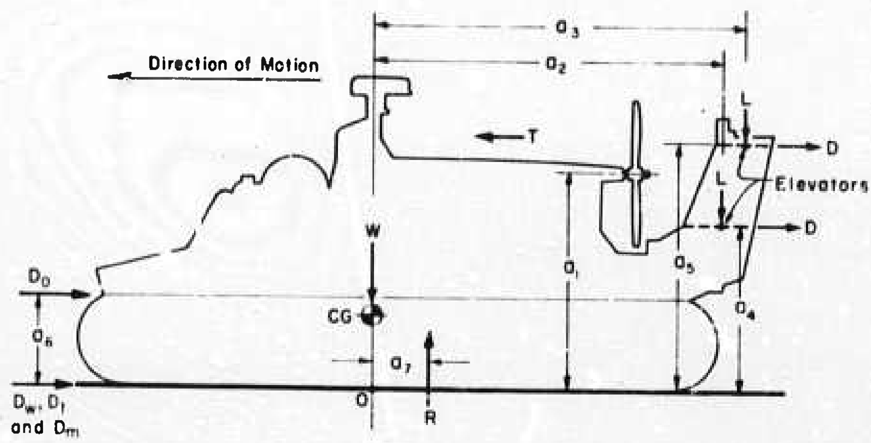

Figure 24. Force system acting on SK-5 during flight.

producing a violent stop, which can be injurious to passengers. A plough-in is most common when moving downwind with an excessive amount of positive propeller pitch in an attempt to achieve maximum speed. It should be noted that the following discussion refers to operations on inland waterways which are subject to high winds but have a short fetch so that large waves do not build up.

The lower probability of an upwind plough-in can be understood by referring to Figure 24 and by examination of the equilibrium equations. The equations and supporting data were taken from references 3 and 4. The equations of equilibrium are:

$$R = W + 2L \tag{1}$$

where

W = craft weight

R = resultant of force provided by the air cushion and skirt

and L = lift developed by the elevators and the rear of the craft.

$$T = D_0 + D_w + D_t + D_m + 2D \tag{2}$$

where

T = propeller thrust

D_0 = aerodynamic drag

D_w = wave-making drag

D_t = skirt or trunk drag

D_m = momentum drag

D = drag produced by the elevator

and

$$Ta_1 + Ra_7 = L(a_2 + a_3) + D(a_4 + a_5) + D_0 a_6 \tag{3}$$

when moments are taken about point 0 (Fig. 24). The drag and other components will be identified briefly.

Thrust T was obtained from reference 6 and from measurement of power input to the propeller and known propeller characteristics. Early in the CRREL test program, "static" thrust was obtained by measuring thrust for various propeller pitch settings when the craft was secured with a cable. However, it is recognized that the performance of a propeller varies with the speed of the relative wind, so that a thrust measurement at the zero wind conditi.. is not valid for operation with a significant relative wind. Our interest in T was to identify the maximum thrust available for a given pitch setting and a given relative wind. Knowing T, it would be possible to determine whether maximum speed was limited by danger of plough-in or insufficient thrust.

D_0 is the aerodynamic drag and is adapted directly from the relationship developed for aircraft. The equation is:

$$D_0 = \frac{\rho_a S_F C_{D,0}}{2} V_R^2 \qquad (4)$$

where

ρ_a = density of air in slugs/ft³

S_F = frontal area of the craft

V_R = relative wind speed

$C_{D,0}$ = drag coefficient.

$C_{D,0}$ was obtained from reference 4 for the SRN-5 which is close enough in form to the SK-5 to be considered accurate. $C_{D,0}$ for the SK-5 is 0.38 and the frontal area was found to be 190 ft².

D_w is the drag resulting from the fact that the air cushion produces a deflection in the water beneath the craft. As the SEV moves forward, the deflection becomes a wave. At a relatively low speed, the wave and craft move at the same speed so that the craft is continually climbing a slope. This speed is identified as the hump speed and the wave-making drag is at a maximum. As speed is further increased, the wave can no longer keep up with the craft and the drag reduces. D_w is given by:

$$D_w = \frac{4 P_c^2 b}{\rho_w g} f_\ell \qquad (5)$$

where

P_c = cushion pressure (28 lb/ft²)

b = width, or beam, of air cushion (19 ft)

ρ_w = density of water in slugs/ft³

g = gravity constant

f_ℓ = a dimensionless number obtained from Figure 25.

Figure 25 was taken from reference 3 and only includes the curve for a length to beam ratio of 6:1. The maximum point of the f_ℓ curve occurs at the hump speed.

D_t is the skirt or trunk drag and attempts to account for the fact that the flexible skirt comes into physical contact with the water surface when the water becomes rough. As will be discussed later, this drag component can be of almost primary importance when operating in rough water. D_t is given by:

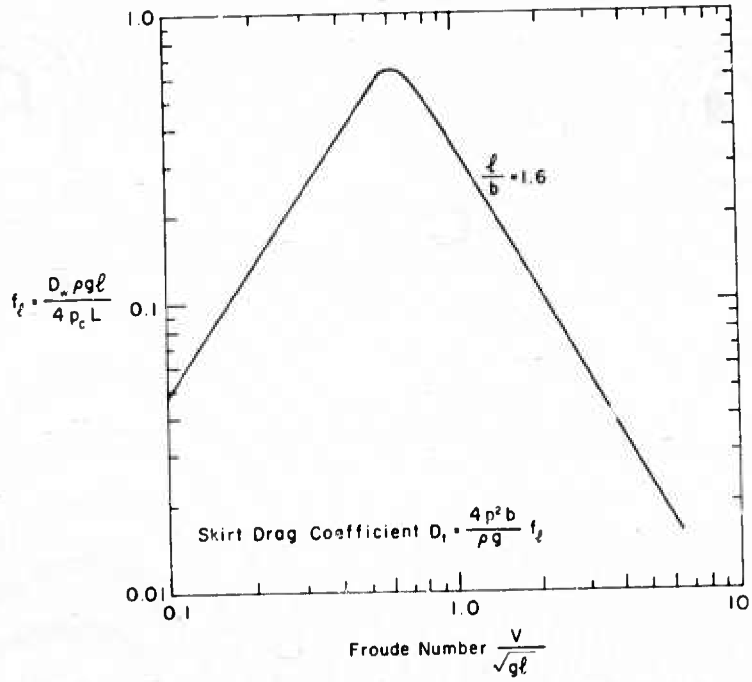

Figure 25. Curve for determination of skirt drag coefficient.

$$D_t = \frac{\rho_a S_c C_{D,t}}{2} V_G^2 \tag{6}$$

where

S_c = cushion area (520 ft²)

V_G = ground speed

$C_{D,t}$ = the drag coefficient and is estimated from:

$$C_{D,t} = 6.6 \left(\frac{H - 2h}{\ell}\right)^{1.2} \tag{7}$$

where

H = wave height in ft

h = air gap (0.208 ft)

ℓ = length of air cushion (32.1 ft).

D_m is the momentum drag and accounts for the fact that the air cushion consists of a constant flow of air into the lift fan, and into the chamber and skirts, and is exhausted through the air gap between the flexible skirt and the ground surface. Because of the constant flow, it is necessary that the cushion and the resulting momentum change produce a drag component given by:

$$D_m = \rho_a v V_G \tag{8}$$

where

v = the air flow rate in ft³/sec.

D is the drag created by the trim elevator located to the rear of the craft and in the airstream of the propeller. The elevator drag is a function of the angle of attack of the elevator and is given by:

$$D = \frac{\rho_a S_E C_D}{2} V_j^2 \tag{9}$$

where:

S_E = area of the elevator (19.9 ft²)

C_D = coefficient of drag

C_D was selected for a standard Clark-Y foil having a maximum lift at an 18° angle of attack. C_D = 0.175.

V_j = the "jet" velocity on the downwind side of the propeller.

V_j is obtained from:

$$V_j^2 - V_R V_j - T/\rho_a S_D = 0 \tag{10}$$

in which S_D is the propeller disk area, that is, the area swept by the propeller. The lift developed by the elevator is given by:

$$L = \frac{\rho_a S_E C_L}{2} V_j^2 \tag{11}$$

where

C_L = the coefficient of lift, taken as 1.35.

In order to compute the likelihood of a plough-in, it was assumed that a plough-in would have a high potential if equilibrium required the resultant R of the vertical forces to be forward of the center of gravity. The solution was rudimentary but mildly tedious so will not be inflicted upon the reader. However, the computations indicated that a craft of the SK-5 configuration operating in a 23-mph wind with 1-ft-high waves could operate at 50 ft/sec (34.3 mph) downwind and 80 ft/sec (54.8 mph) upwind. This major difference is accounted for by the aerodynamic drag and the lift and drag developed by the elevator. Both of these components are functions of the relative wind: moving downwind at 50 ft/sec the relative wind is 16.4 ft/sec while moving upwind at 80 ft/sec, the relative wind is 113.6 ft/sec. A better comparison is the relative wind in each direction for a fixed ground speed: for V_G = 60 ft/sec, the upwind relative wind is 93.6 ft/sec and for downwind it is 26.4 ft/sec. Obviously the thrust requirements are reduced when moving downwind but on inland waters with low waves, the effects of the thrust are less than the effects of the drag components.

However, in large bodies of water an opposite situation exists and downwind operation produces a higher speed than can be achieved going upwind. If in the example selected the waves associated with a 23-mph wind blowing over a long body of deep water would produce 3-ft-high waves instead of the 1 ft selected, at a speed of 80 ft/sec upwind, the skirt or trunk drag becomes in excess of 1400 lb, a more than six-fold increase over the skirt drag for a 1-ft-high wave. The craft becomes limited by inadequate thrust and the upwind speed becomes less than the downwind speed.

Procedure: The procedure used to determine speed was to measure with a stopwatch the time required to move between two points at a known distance apart. The two points were approximately 3500 ft apart so that minor speed differences were filtered.

Results. The tests conducted on Portage Canal involved waves less than 1 ft high with winds in the range of 18 to 23 mph. The downwind speed was found to be 43 mph and the upwind speed was 55 mph. These numbers appear credible in view of the computed values. More realistically, the computed numbers are credible in view of the measured values.

Measurement of weight

Objective. The objective of this test was to obtain the weight of the craft as used during the test program and to establish the amount of support provided by the cushion air when the engine was idling.

Background. It was necessary to obtain craft weight for several reasons, such as computing slope climbing ability and maximum speeds, and for use in describing the SK-5 as a load. (Early in the test program, the SK-5 was used in conjunction with a research study dealing with deflection of ice as a function of ice thickness and duration of loading.)

Two weights were of concern: the gross weight of the vehicle and the weight borne by the landing pads. The craft has four circular landing pads that support most of the weight in the absence of cushion air. It was initially assumed that the support provided by the cushion air when the engine was idling was so low that it could be ignored. This assumption was questioned by the test pilot, and as a result it was decided that the load on the pads would be measured for both situations: with the engine idling and with the engine stopped.

Procedure. To measure the gross weight, a 20,000-lb-capacity load cell was used. A sling with four cables attached between a spreader bar and the four lifting points of the vehicle was constructed (Fig. 26). A single cable was attached to the spreader bar and the load cell was attached between the cable and the lifting hook of a 20-ton GarWood mobile crane. Once the sling was attached, the vehicle was raised high enough so that the skirt was completely free of the ground.

A hydraulic pressure cell (Fig. 27) was used to measure the load on each pad. The cell was high enough so that it bore the full weight normally carried by the two front pads but not so high as to cause a shift of the CG due to movement of liquids. The craft was lifted and the cell placed in position below the pad and the vehicle was then lowered until the cable was slack. The weight was read, the engine started and the weight re-read. The craft was then lifted and the cell moved to a new position. The procedure was repeated until the load on all four of the pads was established.

Results. The craft weight with 150 gallons of fuel (half full tanks) was found to be 13,690 lb. A tabulation of the weights gives:

Gross weight	13,690 lb
Weight on pads, engine not running	11,110
Weight supported by skirt	2,580
Weight on pads, engine idling	6,900
Weight supported by skirt	2,080
Weight supported by cushion	4,710

The cushion air force of 4710 lb produced by the idling engine may seem large until it is realized that the cushion area is 520 ft² so that a cushion pressure of 0.063 psi is all that is required.

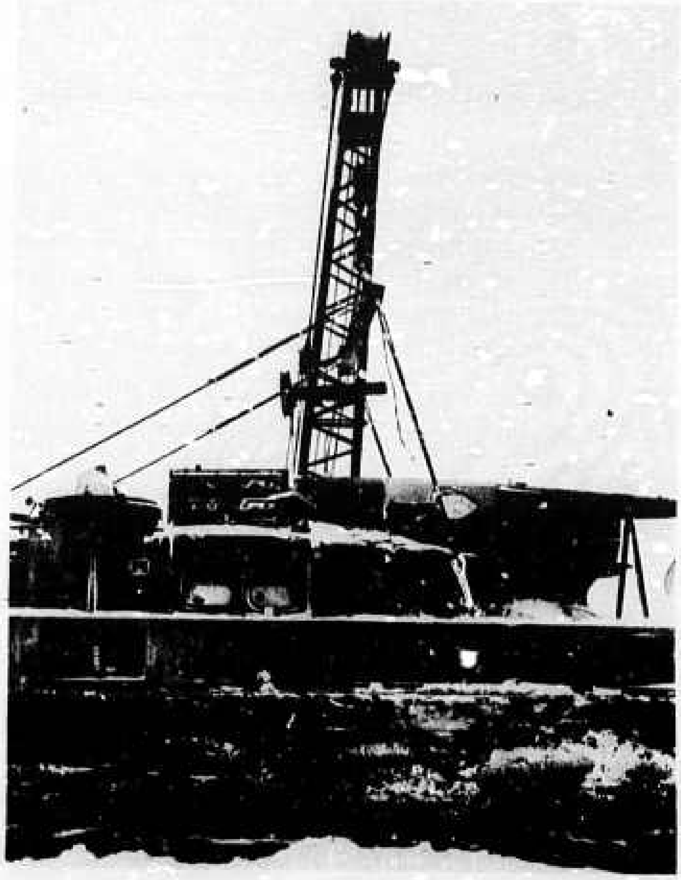

Figure 26. Sling and spreader bar for lifting SK-5.

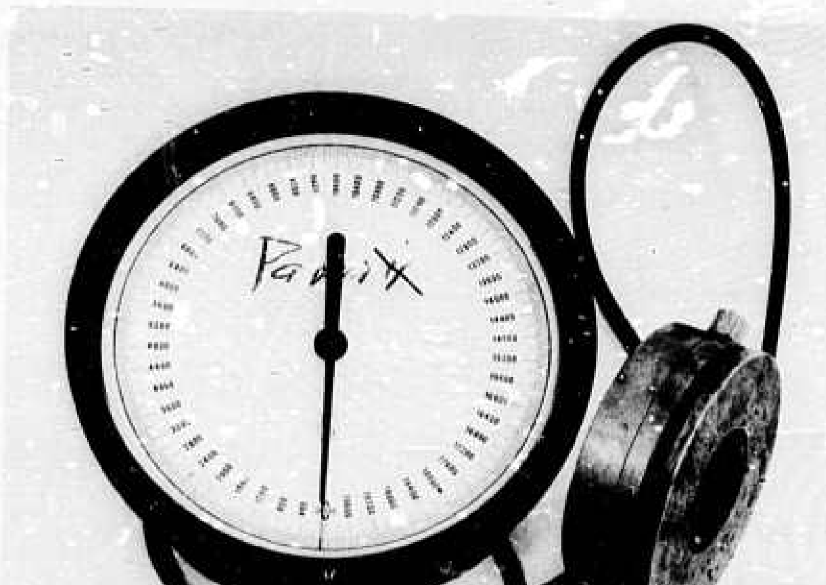

Figure 27. Hydraulic sensor and gage to measure loads on landing pads.

Measurement of drag

Objective. The objective of this test was to obtain a measure of skirt drag over a variety of surfaces.

Background. The flexible skirt of an SEV is both its major source of success and its major source of design and development problems. A contributor to the design and development problems of amphibious SEV s is a lack of knowledge of the drag which results during operation on solid surfaces. Drag caused by mechanical contact between the skirt and ground can result in damage from abrasion. It appeared useful, therefore, to obtain drag readings for several surfaces in order to compare the results with the drag developed when operating on water.

Procedure. The procedure on land and water was essentially the same except that a boat was used in deep water as the prime mover. A cable was connected between the craft and a load cell mounted on the towing vehicle. The cable was attached in a way that eliminated any turning moment but pulled at an angle to the horizontal so that the front of the SEV was pulled slightly down. When the cable was attached, the SEV was put on full cushion and it was then dragged slowly forward with continuous monitoring of the reading on the load cell. The speed was kept low enough that the speed-sensitive drag parameters could be considered zero and the propeller was set to zero thrust so that the only force being measured was due to direct interaction, not necessarily physical contact, between the skirt and surface.

Two sets of overwater drag data were desired: below and above hump speed in shallow water and below and above hump speed in deep water. In these tests it was impossible to exceed hump speed in shallow water because the towing vehicle did not have adequate power to overcome both the drag of the SK-5 and its own motion resistance and have power left over for acceleration. The shallow water tests were run in Site 3 (Fig. 1) and the deep water tests in Site 2. Site 3 allowed measurement of drag over marsh, over marsh with a thick brush cover, over marsh with a thin brush cover, over grass, and over shallow water.

The prime mover for the tests conducted in Site 3 was a Thiokol Spryte: a full-tracked light carrier. A boat powered by a 265-hp inboard engine was used as prime mover for the deep water tests. The hitch point for the Spryte was approximately 18 in. above the ground while the hitch point for the boat was approximately at water level. In order to eliminate the effect of the wake from the boat as much as possible, a 200-ft tow rope was used.

Results. The results of the drag tests were as follows:

Grassy, dry surface	170 lb
Marsh (live mat over water)	225
Marsh with dense brush	460
Marsh with thin brush	230
Shallow water, below hump, 10 mph	945
Deep water	
Below hump speed	545
Above hump speed	425

The results were reasonably close to expectations even though the towline was at an angle. For example, using the equations presented in the previous section, the drag below hump speed is predicted as 610 lb. Because of the angled towline, it was suspected that the error, if any, would be on the high side. However, with a 200-ft towline, the 545-lb pull would only have a vertical

component of 19 lb. The major difference in drag between shallow and deep water is well known. It has been observed by almost all SEV pilots that it is much more difficult to accelerate above hump speed in shallow water than in deep water. In fact in some cases it is not possible to get above hump speed until the surface has been stirred up by the craft thrashing about.

Although the surface of the marsh and the grass-covered surface didn't appear greatly different, the structure of the marsh seemed to imply that skirt drag over it would be greater than the drag over ground unless the grass cover was deep and thick. The marsh on which the tests were conducted has a floating live mat varying in thickness from 6 to 9 in. The water provides support for the vehicle with the live mat acting as a porous upper surface. The air gap is thus between the water and the skirt so that the skirt produces a local deformation of the mat between 3½ and 6½ in. The ground, on the other hand, provides support from the grass covered surface. Since the grass was only a few inches deep, there was much less physical contact between the skirt and the vegetation.

The presence of brush will obviously increase drag simply because the brush must be deflected enough to allow passage of the craft. It is suspected that thick brush having a height of about half the flexible skirt height would immobilize the SK-5.

Even though the skirt drag numbers obtained in this test appear to be in the right "ball park," it is suggested that the technique is not correct. The towline is an obvious source of error; and the tests were confined to locations negotiable by a vehicle of some sort. It would seem better to measure changes in speed while moving over the surface of interest with zero propulsive force. It is possible that relationships between skirt drag and speed could be obtained for any surface of interest. This requires more faith in the equations describing aerodynamic and momentum drag than is possessed by the writer. However, if skirt drag at low speeds is adequate, the measurement of deceleration and subsequent computation of drag is straightforward and should produce reliable and accurate results. This technique was applied to subsequent tests at Fort Greely, Alaska.

Study of obstacle performance

Objective. The objective of this test was to investigate the relationship between the dynamic response of an SEV and the geometric form of an obstacle.

Background. Early attempts by CRREL personnel to conduct experimental studies of the dynamic behavior of the SK-5[8] were of questionable value because the effect of the operator was not accounted for. That is, the operator was instructed to approach various obstacles at what he considered to be the maximum safe speed. Analysis of the resulting data made it immediately apparent that the highly skilled test pilot was approaching the obstacles at a speed which experience told him would produce acceptable levels of pitch, surge and heave. It was concluded that future experiments should be based on mathematical descriptions of SEV dynamics that are now being developed.

This experiment ignored that advice in part but did attempt to measure all the parameters that intuition identified as important. Thus, the geometric forms of the obstacles were carefully measured and recorded; speeds approaching and on the course were recorded; and the records of pitch, roll yaw, heave, surge, roll rate and yaw rate were marked to permit correlation with course position.

Because of the exigencies of time, the test results have not been related to predicted behavior based on several sets of equations that are reported as being available. Specifically, both the Grumman and Boeing Aircraft companies report, orally, that they have written equations describing SEV dynamic responses. A follow-on report will be prepared by the writer comparing actual and predicted results However, the test data will be provided in this report so that others may use them immediately rather than awaiting the education of the writer.

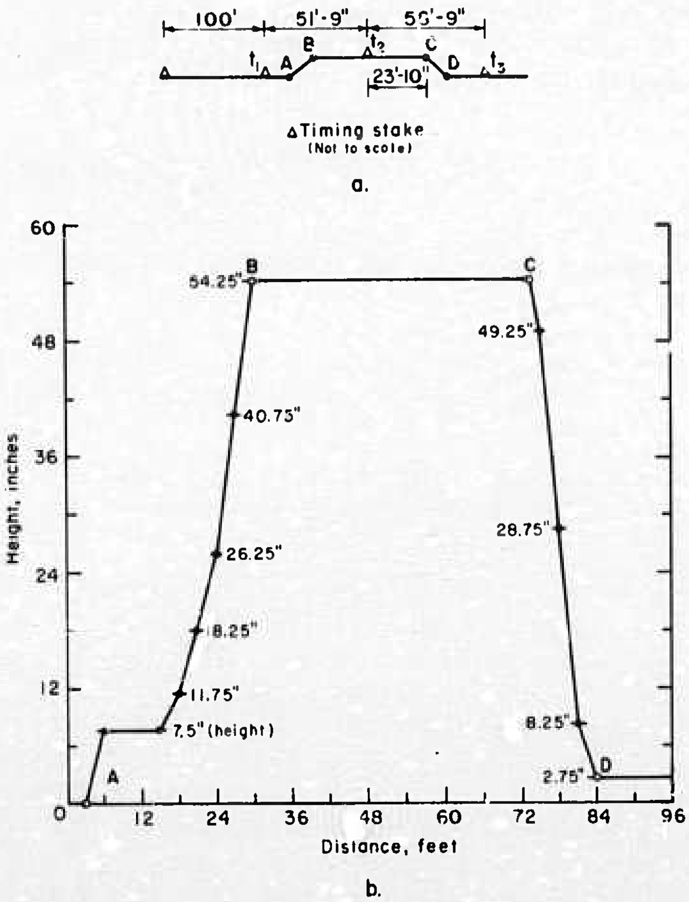

Figure 28. Profile of obstacle no. 1.

The tests were conducted on the Isle Royale Sands using four different obstacles. Although all of the obstacles were artificially created, one of them, identified as obstacle 3, had been created by removal of sand for commercial operations. It was modified slightly for the test but could, in a vague sense, be considered a natural obstacle in that it had been exposed to the elements for several years. The profiles are shown in Figures 28-31. Photographs of the obstacles are presented in Figures 32-35.

Procedure. Because of the difficulty of obtaining precise speed control of the SK-5, general engine and propeller pitch settings were specified but these were taken to establish the speed range. The actual speed entering and on the course was measured by recording time between known points on the course.

Instruments developed by the Stevens Institute of Technology were installed to measure pitch, roll, yaw, heave (vertical acceleration) and surge (horizontal acceleration). Pitch, roll and yaw rates could be derived from the record of the pitch, roll and yaw since the paper speed was known, giving a time base.

The test procedure was simple: the obstacle was selected and the craft positioned several hundred feet away so that the speed could be stabilized before the obstacle was encountered. The instrument operator signified that his instruments were ready; the craft was lifted on cushion and the appropriate power and propeller settings made. As the craft approached the obstacle, the timing

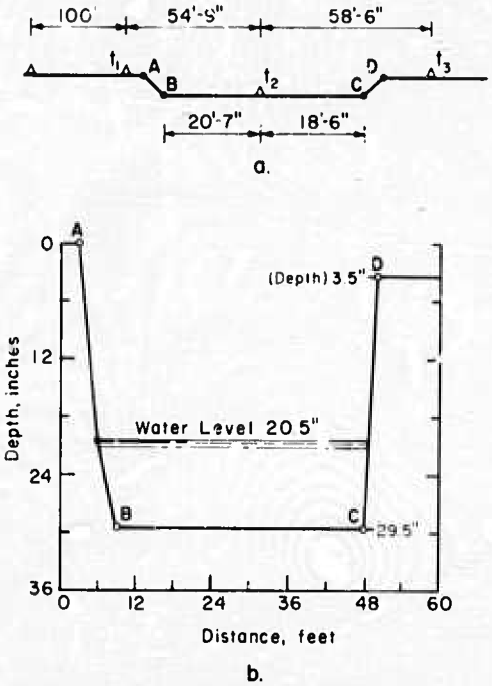

Figure 29. Profile of obstacle no. 2.

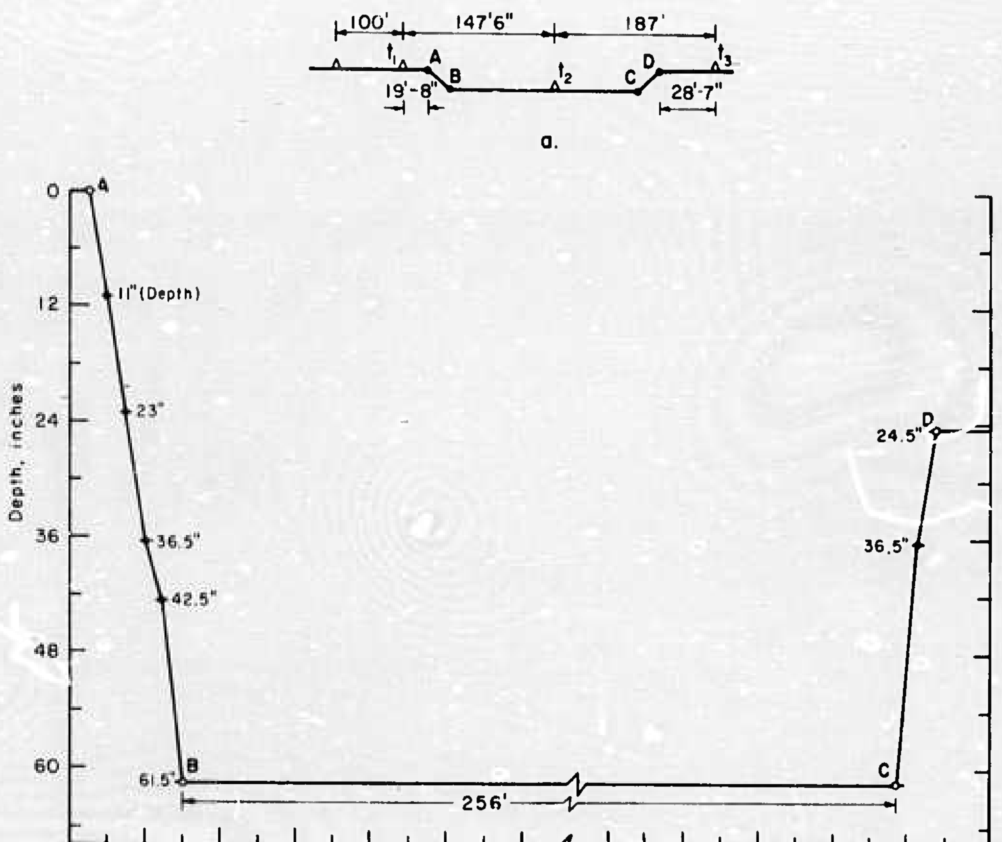

Figure 30. Profile of obstacle no. 3.

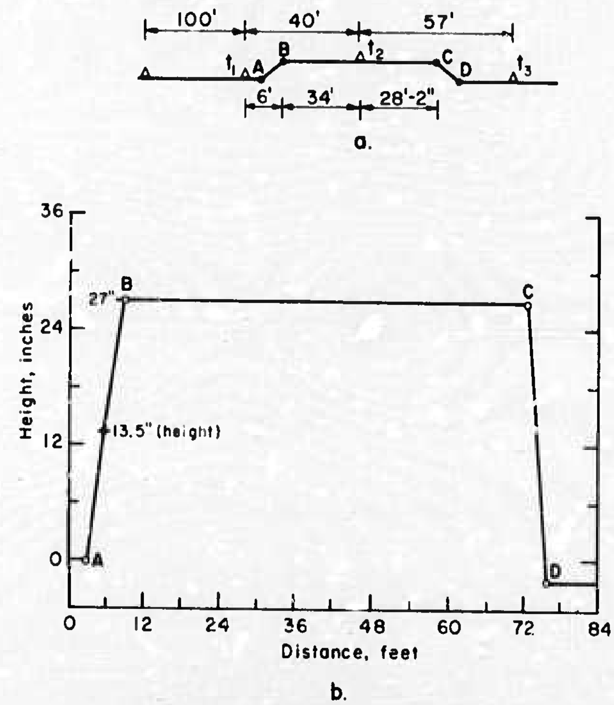

Figure 31. Profile of obstacle no. 4.

Figure 32. Obstacles no. 1 and 4 on Isle Royale Sands.

Figure 33. Obstacle no. 2.

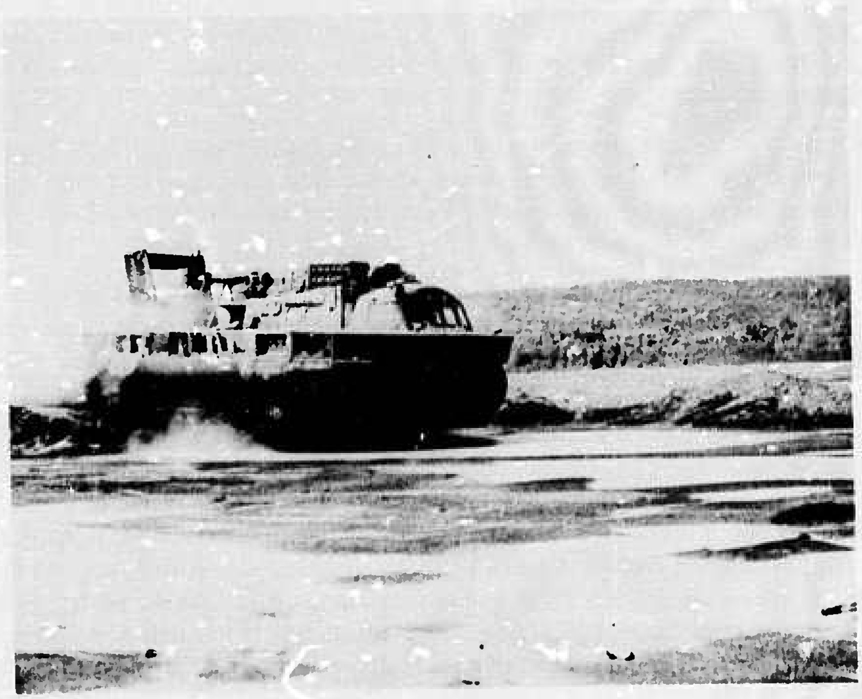

Figure 34. Obstacle no. 3.

Figure 35. Obstacle no. 3.

cycle was initiated at the first timing stake. It was not possible to maintain a constant propeller setting while negotiating the entire obstacle. For example, it was necessary to "zero" the propeller pitch prior to striking obstacles having a sharp, positive vertical rise (see Fig. 35) in order to provide maximum cushion. If the air cushion is not set at a maximum there is danger that hard structure impact will occur which can result in significant damage to the vehicle. However, speed was monitored over several sections of the obstacle so that a reasonably accurate identification of speed was obtained.

Results. The results are given in the Appendix. No analysis of the data has been made beyond plotting the relationships between vehicle speed and the several dynamic parameters. The plots are not included in the report because they are considered misleading and confusing without benefit of analytical prediction of response behavior.

Although it may seem begging the point, the writer does not feel it appropriate to discuss the test results. They are included so that readers having both the need for and competence to use the data may have them without delay. A subsequent report will deal with this phase of the test in detail.

Conclusion

It is difficult to set down a single conclusion, or for that matter several conclusions, concerning as heterogeneous a set of tests as are reported herein. In some cases, a considerable effort was required to obtain and report data that are of little consequence unless they are of abiding interest to the reader. In other cases, little effort was required to establish and report a perhaps severe limitation to the operating range of SEV's. It seemed important to the writer, however, to report all of the things learned since the SEV remains a generally misunderstood vehicle form that will need many more man-years of research, development and testing before its behavior is understood by technicians developing it and operators using it.

The findings of each of the tests are listed with no amplification since they were adequately discussed in the individual sections.

Operation on railroad beds. SEV's of the size of the SK-5 or greater are incapable of operating on railroad beds.

Operation on secondary roads. SK-5's cannot cope with the crown on secondary roads because the roads are too narrow.

Establishment of maneuver requirements. A path width approximately three times the length of the SEV is required for uninhibited operation on hard surfaces.

Operation on inland waterways. SEV's can operate with ease on rivers whose width is twice the length of the craft if the river is deep enough to float the craft, free of surface obstacles such as bridges and fallen trees, and familiar to the operator of the craft.

Measurement of water speed. Upwind speed was found to be greater than downwind speed for inland waterways in which wave height tends to be lower for a given wind velocity than would occur on open water. With a wind varying between 17 and 23 mph, the downwind speed was approximately 43 mph and the upwind speed was approximately 55 mph.

Measurement of weight. The weight borne by the parking pads and skirts with and without the engine idling was measured. It was found that for a gross weight of 13,690 lb the pads bore 11,110 lb and the skirt 2080 lb, with the engine not running. With the engine at idle, the air cushion supported 4710 lb.

Measurement of drag. The drag measurements are listed below:

1. Grassy, dry surface	170 lb
2. Marsh (live mat over water)	225
3. Marsh with dense brush	460
4. Marsh with thin brush	280
5. Shallow water, below hump	945
6. Deep water, below hump	545
7. Deep water, above hump	425

Study of obstacle performance. The data appearing in the Appendix cannot be summarized at this time.

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APPENDIX A

Table AI. Tabulation of entry and on-course speeds, obstacle 1, 14 June 1971 (see Fig. 28a).

Run	d_1 = 100 ft		d_2 = 51 ft 9 in.		d_3 = 58 ft 9 in.	
	t_1 (sec)	Speed (mph)	t_2 (sec)	Speed (mph)	t_3 (sec)	Speed (mph)
1*	3.5	19.5	2.3	15.5	2.2	18
2*	3.1	22	2.9	12	2.0	20
3	3.1	22	2.1	17	-	-
4	3.5	19.5	2.7	13	4.3	9
5	3.0	23	1.6	22	3.1	13
6	3.0	23	2.1	17	3.1	13
7	3.2	21	2.2	16	3.4	12
8	3.1	22	2.4	15	3.1	13
9	3.2	21	2.3	15.5	3.1	13
10	2.8	24	1.4	25.5	3.1	13
11	3.0	23	-	1	-	-
12	2.7	25	2.1	17	2.4	16.5
13	2.8	24	1.5	24	3.1	13
14	2.8	24	2.0	18	3.1	13
15	2.9	23	1.9	19	2.5	16
16	-	-	-	-	-	-
17	1.8	38	1.2	30	2.0	20
18	1.8	38	1.0	36	2.0	20
19	2.0	34	0.8	45	2.1	19
20	2.4	28	0.7	51	2.2	18
21	1.8	38	1.0	36	2.1	19
22	4.2	16	2.3	15.5	4.6	9.0
23	5.0	13.5	2.8	13	6.4	6.3
24	3.8	18	2.2	16	4.0	10

*Dynamic response data were not usable.

Table AII. Dynamic response data, obstacle 1, 14 June 1971 (see Fig. 28b).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 3 (Max pitch 14°/sec, max roll 5.5°/sec, max yaw 7°/sec)					
Max*	0.52	0.32	−13.0	3.5	14.0
A−3	0.45	0.24	0	1.0	14.0
A	0.32	0.25	1.5	1.0	14.0
A+3	0.11	0.2	3.0	1.0	14.0
+6	0.28	0.1	5.0	1.0	14.0
+9	0	0.28	7.5	1.0	14.0
B	−0.45	0.3	8.5	0	14.0
B+3	−0.45	0.2	7.5	−0.5	14.0
+6	−0.2	0.10	5.5	−1.0	14.0
+9	0.25	0.03	3.0	−1.0	14.0
C−3	−0.26	0.25	− 2.5	+0.5	14.0
C	−0.26	0.27	− 5.0	0.5	1.0
C+3	0.22	0.06	− 8.0	1.5	1.0
D	0.1	0.19	−13.0	3.0	1.0
D+3	0.1	0.30	−13.0	3.5	1.0
+6	0.1	0.32	−11.5	3.0	1.0
+9	0.1	0.06	−10.0	3.0	1.0
Run 4 (Max pitch 15°/sec, max roll 4.5°/sec, max yaw 3°/sec)					
Max	0.6	0.32	−14.0	2.0	18.0
A−3	0	0	0	1.0	3.0
A	0	0	0	1.0	3.0
A+3	0	0	0	1.0	4.0
B	0	0	0	1.0	5.0
B+3	0	0	0	1.0	6.0
+6	0	0	0	1.0	7.0
+9	0	0	0	0.5	8.0
C−3	−0.32	0.08	6.0	−1.0	13.0
C	+0.32	0	2.0	−0.5	14.0
C+3	−0.16	0	− 1.0	0	15.0
D	0	0.07	− 3.5	0	15.0
D+3	−0.33	0.21	− 3.0	0	16.0
+6	−0.33	0.21	− 5.0	0	16.0
+9	0	0	− 8.0	0	17.0

*The maximum values seldom appear in the tabulation because they did not occur at a reference position. For instance, in run 3 the maximum heave of 0.52 g was recorded *between* positions A minus 3 ft and A (Fig. 28b).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 5 (Max pitch 18.5°/sec, max roll 6.5°/sec, max yaw 7°/sec)					
Max	0.53	0.22	− 9.5	5.0	17.0
A−3	0.31	0.09	− 0.5	3.0	2.0
A	0.34	0.18	0.5	2.5	2.0
A+3	0.32	0.2	2.0	2.0	3.0
+6	0.23	0.09	4.5	1.0	3.0
+9	0	0.13	7.0	0	4.0
B	−0.25	0.21	9.0	−2.0	5.0
B+3	−0.18	0.12	7.0	−2.0	5.0
+6	0.15	0	4.0	−1.5	6.0
+9	0	0	2.0	−1.0	7.0
C−3	−0.32	0.10	− 1.5	2.0	17.0
C	−0.11	0.22	− 4.0	2.5	16.0
C+3	0.53	0	− 7.0	2.5	15.0
D	−0.11	0.18	−10.0	3.5	15.0
D+3	0	0.19	− 9.5	4.0	14.0
D+6	0	0.18	− 9.5	4.0	13.0
+9	0	0.18	− 9.0	4.0	12.0
Run 6 (Max pitch 24.5°/sec, max roll 5.5°/sec, max yaw 5°/sec)					
Max	0.46	0.25	−13.0	4.5	10.0
A−3	0.46	0.13	0	2.5	0
A	0.41	0.25	0	2.0	0
A+3	0.42	0.23	1.0	2.0	0
+6	0.19	0.17	2.5	1.5	1.0
+9	0.28	0.10	4.0	1.0	1.0
B	−0.22	0.22	8.0	0	2.0
B+3	0	0.20	8.5	−0.5	2.0
+6	−0.35	0.18	8.5	−1.5	3.0
+9	−0.43	0.14	7.5	−2.0	4.0
C−3	−0.28	0.17	− 2.0	1.5	9.0
C	−0.35	0.18	− 3.0	1.5	9.0
C+3	−0.39	0.15	− 5.0	1.5	9.0
D	0.08	0.14	−12.0	4.0	9.0
D+3	0.10	0.20	−13.0	4.5	9.0
+6	0.11	0.25	−13.0	4.5	9.0
+9	0.12	0.25	−11.5	4.5	9.0

Table AII (Cont'd).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 7 (Max pitch 20°/sec, max roll 11°/sec, max yaw 5°/sec)					
Max	0.56	0.31	−12.5	4.5	15.0
A−3	0.55	0.19	− 0.5	0.5	0
A	0.42	0.24	0	0	0
A+3	0.43	0.31	1.0	0	0
+6	0.29	0.21	3.0	−0.5	0
+9	0.30	0.12	5.0	−0.5	0
B	−0.30	0.21	8.0	−1.0	0
B+3	−0.15	0.21	9.0	−1.0	1.0
+6	−0.29	0.20	8.5	−1.0	1.0
+9	−0.12	0.11	7.5	0	1.0
C−3	−0.22	0.12	− 1.0	2.5	7.0
C	−0.41	0.15	− 0.5	3.0	8.0
C+3	−0.35	0.18	− 1.0	3.5	9.0
D	0	0.21	− 5.5	4.5	10.0
D+3	0.56	0	− 8.5	4.5	11.0
+6	0.15	0.19	−11.0	4.0	12.0
+9	0.1	0.19	−12.0	4.0	13.0
Run 8 (Max pitch 23°/sec, max roll 5.5°/sec, max yaw 2°/sec)					
Max	0.5	0.28	−12.5	2.0	4.0
A−3	0.11	0.05	− 1.0	0	0
A	0.31	0.07	− 0.5	0	0
A+3	0.35	0.28	0	0	0
+6	0.25	0.24	1.5	0	0
+9	0.08	0.20	3.0	0	0
B	0	0.21	6.5	0	0
B+3	−0.21	0.13	8.5	0	0
+6	−0.3	0.22	9.0	−0.5	1.0
+9	−0.4	0.22	9.0	−0.5	1.0
C−3	0.21	0.03	− 2.5	0	3.0
C	0.11	0.05	− 1.5	0	3.0
C+3	−0.32	0.08	− 1.0	0	3.0
D	−0.31	0.17	− 2.0	0	3.0
D+3	−0.3	0.20	− 4.5	0	3.0
+6	0.26	0.12	− 7.0	+1.0	3.0
+9	0.1	0	−10.0	+1.5	3.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 9 (Max pitch 22°/sec, max roll 6°/sec, max yaw 5°/sec)					
Max	0.48	0.28	−13.0	3.0	12.0
A−3	0.38	0.21	0	0.5	4.0
A	0.28	0.28	1.0	0.5	4.0
A+3	0.26	0.15	3.0	0.5	4.0
+6	0.42	0.10	5.5	0.5	5.0
+9	−0.16	0.22	7.5	0	5.0
B	−0.30	0.28	9.0	−0.5	6.0
B+3	−0.31	0.22	8.0	−0.5	6.0
+6	−0.29	0.11	6.0	−0.5	7.0
+9	0	0	4.0	−0.5	7.0
C−3	−0.48	0.11	− 1.0	0	12.0
C	−0.41	0.22	− 1.0	−0.5	12.0
C+3	−0.4	0.28	− 2.0	−0.5	12.0
D	−0.3	0.2	− 5.5	0	12.0
D+3	0.31	0	− 9.0	1.5	12.0
+6	0.22	0.05	−12.0	2.0	12.0
+9	0.07	0.14	−12.5	2.5	12.0
Run 9B (Max pitch 23°/sec, max roll 7°/sec, max yaw 1.0°/sec)					
Max	0.6	0.26	−13.0	4.4	3.0
A−3	0.17	0.05	− 1.0	2.0	0
A	0.18	0.10	− 0.5	2.0	0
A+3	0.5	0.14	0	1.5	0
+6	0.32	0.22	1.0	1.5	0
+9	0.19	0.13	3.0	1.0	0
B	0	0.13	6.5	0.5	1.0
B+3	−0.10	0.23	9.0	0	2.0
+6	−0.39	0.26	9.0	0	2.0
+9	−0.35	0.18	8.5	0	2.0
C−3	−0.42	0.33	− 1.5	1.0	3.0
C	−0.31	0.20	− 2.5	1.0	3.0
C+3	−0.3	0.22	− 5.0	1.0	3.0
D	0.06	0.10	−11.5	3.5	3.0
D+3	0.09	0.20	−13.0	4.4	3.0
+6	0.13	0.23	−11.5	4.0	3.0
+9	0.18	0.24	−10.5	4.0	3.0

Table AII (Cont'd). Dynamic response data, obstacle 1, 14 June 1971 (see Fig. 28b).

Run 10 (Max pitch 19°/sec, max roll 8.5°/sec, max yaw 2°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.62	0.30	−12.5	3.5	3.0
A−3	0.13	0	− 1.0	0.5	1.0
A	0.2	0.08	− 0.5	0.5	1.0
A+3	0.50	0.14	0	0.5	0
+6	0.49	0.23	1.0	0.5	0
+9	0.35	0.28	2.0	0.5	0
B	0.43	0.05	5.5	0	0
B+3	0	0.18	7.0	0	0
+6	0	0.19	8.5	−0.5	0
+9	−0.38	0.2	9.0	−1.0	0
C−3	0	0.30	− 3.5	1.0	0
C	−0.16	0.22	− 5.0	1.0	0
C+3	0.27	0	− 8.0	1.5	0
D	0.09	0.19	−12.5	3.0	0
D+3	0.09	0.26	−12.0	3.0	0
+6	0.12	0.19	−10.0	3.5	0
+9	0.34	0.12	− 7.0	3.0	0

Run 11 (Max pitch 26.5°/sec, max roll 6°/sec, max yaw 0°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.55	0.34	−12.5	3.0	0
A−3	0.23	0.14	− 0.5	0.6	0
A	0.43	0.25	0	0.5	0
A+3	0.36	0.3	1.0	0.4	0
+6	0.22	0.2	2.5	0	0
+9	0.28	0.10	4.5	0	0
B	−0.55	0.32	8.5	−1.0	0
B+3	−0.5	0.26	9.0	−1.5	0
+6	−0.51	0.19	8.5	−2.0	0
+9	−0.5	0.18	7.0	−2.0	0
C−3	−0.12	0.32	− 3.5	1.0	0
C	−0.23	0.27	− 5.0	1.0	0
C+3	0	0.10	− 7.0	1.0	0
D	0	0.17	−12.0	2.5	0
D+3	0.08	0.25	−12.5	3.0	0
+6	0.13	0.28	−12.0	3.0	0
+9	0.16	0.25	−10.5	3.0	0

Run 12 (Max pitch 29°/sec, max roll 4°/sec, max yaw 1°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	−0.51	0.28	−13.5	3.0	2.0
A−3	0.21	0	− 0.5	1.0	0
A	0.45	0.19	0	0.5	0
A+3	0.35	0.27	0.5	0	0
+6	0.16	0.27	2.5	0	0
+9	0.25	0.27	4.5	−0.5	0
B	−0.30	0.28	8.0	−1.0	0
B+3	−0.43	0.27	9.0	−1.0	0
+6	−0.46	0.22	8.5	−1.5	0
+9	−0.51	0.12	7.5	−1.5	0
C−3	−0.18	0.26	− 4.5	1.0	0
C	−0.29	0.23	− 6.0	1.0	0
C+3	0.19	0.04	− 9.5	1.5	0
D	0.04	0.19	−13.5	2.0	0
D+3	0.06	0.20	−12.5	2.0	0
+6	0.08	0.21	−11.0	2.5	0
+9	0.09	0.16	− 9.0	2.0	0

Run 13 (Max pitch 23°/sec, max roll 8°/sec, max yaw 1°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.73	0.25	−12.5	3.6	−2.0
A−3	0.45	0.10	0	0.5	−2.0
A	0.46	0.24	1.0	0.2	−2.0
A+3	0.40	0.25	1.5	0	−2.0
+6	0.18	0.19	3.0	0	0
+9	0.41	0	5.0	−0.5	0
B	−0.35	0.25	8.5	−1.2	0
B+3	−0.34	0.28	9.5	−1.5	0
+6	−0.33	0.21	9.0	−2.0	0
+9	−0.48	0.17	8.0	−2.5	0
C−3	−0.12	0.24	− 3.0	1.0	0
C	−0.29	0.25	− 4.0	1.0	0
C+3	0	0.10	− 6.5	1.0	0
D	0	0.14	−1[illegible].5	3.0	0
D+3	0.14	0.18	−12.5	3.4	0
+6	0.13	0.21	−11.0	3.5	0
+9	0.19	0.22	−11.0	3.6	0

Table AII (Cont'd).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 14 (Max pitch 23.5°/sec, max roll 8.5°/sec, max yaw 3°/sec)					
Max	0.61	0.31	−12.5	4.5	−5.0
A−3	0.22	0.03	− 1.0	1.0	−5.0
A	0.25	0.10	− 0.5	1.0	−5.0
A+3	0.49	0.22	0	1.0	−5.0
+6	0.35	0.31	1.0	0.5	−5.0
+9	0.14	0.23	3.0	0	−5.0
B	−0.22	0.23	7.0	−1.0	−5.0
B+3	−0.09	0.3	8.5	−1.5	−5.0
+6	−0.28	0.24	8.5	−1.5	−5.0
+9	−0.34	0.23	7.5	−1.5	−5.0
C−3	−0.23	0.24	− 5.0	1.0	−5.0
C	0	0.05	− 7.0	1.5	−5.0
C+3	0.12	0.05	−10.0	2.5	−5.0
D	0.13	0.18	−12.5	4.5	−5.0
D+3	0.16	0.26	−11.0	4.5	−5.0
+6	0.20	0.2	− 9.0	4.0	−5.0
+9	0.22	0.09	− 7.0	3.5	−5.0
Run 15 (Max pitch 27.5°/sec, max roll 5.5°/sec, max yaw 1°/sec)					
Max	0.7	0.36	−13.0	3.0	−2.0
A−3	0.50	0.11	− 3.5	0.5	−2.0
A	0.49	0.26	0.5	0.5	−2.0
A+3	0.24	0.25	1.7	0.4	−2.0
+6	0.21	0.22	4.0	0	−2.0
+9	+0.20	0.24	5.5	0	−2.0
B	−0.10	0.25	8.4	−0.5	−2.0
B+3	−0.16	0.28	8.5	−1.0	−1.0
+6	−0.43	0.29	8.0	−1.5	−2.0
+9	−0.33	0.17	7.0	−1.5	−2.0
C−3	−0.12	0.21	− 5.0	1.0	−2.0
C	−0.13	0.13	− 7.0	1.5	−2.0
C+3	0.26	0.09	−10.0	2.0	−2.0
D	0.07	0.18	−13.0	3.0	−2.0
D+3	0.09	0.26	−12.0	3.0	−2.0
+6	0.11	0.2	−10.0	2.8	−2.0
+9	0.16	0.16	− 8.0	2.8	−2.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 16 (Max pitch 27°/sec, max roll 9°/sec, max yaw 1°/sec)					
Max	0.76	0.47	−13.0	3.5	−3.0
A−3	0.76	0.09	− 0.8	0.5	0
A	0.48	0.37	0	0.5	0
A+3	0.36	0.33	0.5	0.5	0
+6	0.25	0.22	2.0	0.5	0
+9	0.11	0.12	4.0	0	0
B	−0.21	0.47	6.5	−0.5	0
B+3	−0.3	0.40	7.0	−0.5	0
+6	−0.38	0.34	6.5	−1.0	0
+9	−0.47	0.28	6.5	−1.5	0
C−1	−0.73	0.07	− 5.5	0	−2.0
C	−0.64	0.13	0	0.5	−2.0
C+1	−0.41	0.07	− 8.0	1.5	−2.0
D	0.65	0.14	−11.0	3.0	−3.0
D+3	0.61	0.21	−12.0	3.2	−3.0
+6	0.43	0.26	−12.8	3.5	−3.0
+9	0.27	0.29	−13.0	3.5	−3.0
Run 17 (Max pitch 24°/sec, max roll 7°/sec, max yaw 0°/sec)					
Max	1.0	0.35	−13.0	3.5	0
A−3	0.4	0	− 1.5	0	0
A	0.55	0.15	− 1.0	0	0
A+3	0.6	0.3	0	0	0
+6	0.5	0.35	1.5	0	0
+9	0.4	0.35	2.5	0	0
B	0	—	5.0	−0.5	0
B+3	−0.1	—	6.5	−0.5	0
+6	−0.3	—	7.0	−0.5	0
+9	−0.4	—	7.0	−0.5	0
C−3	−0.84	—	− 5.0	1.0	0
C	−0.63	0.10	− 6.0	2.0	0
C+3	−0.6	0.04	− 7.5	2.5	0
D	0.76	0.14	−10.5	4.0	0
D+3	0.46	0.28	−13.0	3.5	0
+3	0.46	0.27	−13.0	3.5	0
+9	0.38	0.25	−13.0	3.5	0

Table AII (Cont'd). Dynamic response data, obstacle 1, 14 June 1971 (see Fig. 28b).

Run 18 (Max pitch 25.5°/sec, max roll 8°/sec, max yaw 0°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.95	0.43	−13.5	4.5	0
A−3	0.55	0.12	− 1.0	0.8	0
A	0.82	0.43	− 1.0	0.8	0
A+3	0.60	0.43	− 1.0	0.8	0
+6	0.33	0.43	0	0.8	0
+9	0.13	0.32	2.0	0.8	0
B	−0.14	0.40	6.0	0.2	0
B+3	−0.18	0.32	6.0	0	0
+6	−0.35	0.20	5.5	−0.5	0
+9	−0.48	0.08	6.5	−1.5	0
C−3	−0.72	0.11	− 6.0	0	0
C	−0.7	0.13	− 7.5	0.5	0
C+3	0.75	0.18	− 9.0	1.5	0
D	0.55	0.17	−13.0	3.5	0
D+3	0.95	0.20	−13.0	4.2	0
+6	0.4	0.21	−12.5	4.5	0
+9	0.6	0.23	−12.5	4.5	0

Run 19 (Max pitch 26°/sec, max roll 6°/sec, max yaw 2°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	+0.9	0.35	−13.0	4.0	5.0
A−3	0.73	0	− 1.2	1.0	2.0
A	0.6	0	− 1.0	1.0	2.0
A+3	0.38	0	− 1.0	1.0	2.0
+6	0.21	0.07	0	1.0	3.0
+9	−0.1	0.13	1.5	0.5	3.0
B	−0.4	0.24	4.5	0	3.0
B+3	−0.58	0.31	6.5	0	4.0
+6	−0.71	0.35	6.0	−0.5	4.0
+9	−0.6	0.34	7.0	−1.0	4.0
C−3	−0.6	0.03	− 5.0	0.5	5.0
C	−0.6	0.05	− 6.5	1.5	5.0
C+3	−0.6	0.1	− 8.0	2.0	5.0
D	0.62	0.18	−11.5	3.5	5.0
D+3	0.62	0.20	−12.5	4.0	5.0
+6	0.50	0.21	−13.0	4.5	5.0
+9	0.35	0.23	−13.0	4.0	5.0

Run 20 (Max pitch 24°/sec, max roll 8°/sec, max yaw 4°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	−0.8	0.5	−12.5	3.5	−13.0
A−3	0.56	0.5	− 1.5	0.5	− 8.0
A	0.43	0.4	0	0.5	− 8.0
A+3	0.25	0.33	1.0	0.5	− 8.0
+6	0.14	0.23	2.5	0.5	− 8.0
+9	0.06	0.20	4.0	0	− 8.0
B	−0.3	0.25	6.5	−0.5	− 8.0
B+3	−0.3	0.31	6.0	−0.8	− 8.0
+6	−0.4	0.33	6.5	−1.0	− 8.0
+9	−0.55	0.34	6.5	−1.0	− 8.0
C−3	−0.75	0.07	− 5.5	0	−11.0
C	−0.68	0.12	− 7.0	+1.0	−11.0
C+3	0.46	0.03	− 9.0	2.0	−11.0
D	0.60	0.28	−12.5	3.5	−11.0
D+3	0.31	+0.28	−12.5	3.5	−12.0
+6	0.23	+0.26	−12.0	3.0	−12.0
+9	0.23	+0.21	−11.0	3.0	−12.0

Run 21 (Max pitch 25°/sec, max roll 10°/sec, max yaw 0°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.9	0.53	−12.5	5.0	0
A−3	0.46	0	− 1.5	0.5	0
A	0.9	0.50	− 1.5	0.5	0
A+3	0.75	0.53	− 1.5	0.5	0
+6	0.55	0.44	− 0.5	0.5	0
+9	0.27	0.37	1.0	0.5	0
B	0	0.22	4.0	0	0
B+3	−0.29	0.18	5.0	0	0
+6	−0.39	0.15	6.0	0	0
+9	−0.45	0.12	6.0	−0.5	0
C−3	−0.77	0.07	− 4.0	0.5	0
C	−0.76	0.08	− 5.0	1.0	0
C+3	−0.72	0.10	− 6.0	1.5	0
D	0.32	0.18	− 9.0	3.5	0
D+3	0.7	0.2	−12.0	4.5	0
+6	0.7	0.25	−12.0	4.5	0
+9	0.7	0.25	−12.5	5.0	0

Table AII (Cont'd).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 22 (Max pitch 17.5°/sec, max roll 5.5°/sec, max yaw 9°/sec)					
Max	0.58	0.24	− 9.5	2.0	17.0
A−3	0.12	0.08	− 1.0	1.0	0
A	0.47	0.18	− 0.5	1.0	2.0
A+3	0.14	0.23	0	0.5	4.0
+6	0.03	0.20	1.7	0	6.0
+9	0.12	0.10	4.0	0	8.0
B	−0.22	0.23	8.5	−0.7	10.0
B+3	−0.3	0.24	8.5	−1.5	12.0
+6	−0.2	0.14	6.5	−2.0	14.0
+9	−0.12	0.05	3.5	−1.5	15.0
C−3	−0.25	0.22	− 2.5	−1.0	17.0
C	0.58	0.05	− 6.5	−2.0	16.0
C+3	0	0.05	− 9.5	−2.0	14.0
D	0	0.12	− 9.5	0.5	12.0
D+3	0	0.15	− 9.5	0.5	11.0
+6	0	0.16	− 9.0	1.0	11.0
+9	0	0.11	− 8.5	1.5	10.0
Run 23 (Max pitch 13.5°/sec, max roll 4°/sec, max yaw 8°/sec)					
Max	0.46	0.20	−10.0	2.5	37.0
A−3	0	0.06	− 0.5	+1.5	20.0
A	0.10	0.15	0	+1.0	21.0
A+3	0.11	0.20	+ 1.0	+1.5	23.0
+6	0.08	0.20	3.0	0	25.0
+9	0	0.09	5.5	0	27.0
B	−0.32	0.20	9.0	−1.5	29.0
B+3	−0.25	0.14	8.0	−2.0	31.0
+6	0.18	0.02	5.5	−1.5	32.0
+9	0	0	3.5	−1.5	33.0
C−3	−0.25	0.07	− 1.0	0	27.0
C	0.13	0	− 4.5	1.0	25.0
C+3	0	0	− 7.5	1.5	23.0
D	0	0.10	− 9.0	0	21.0
D+3	0	0.13	−10.0	1.0	19.0
+6	0	0.13	− 9.0	1.5	17.0
+9	0	0.12	− 8.0	2.0	15.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 24 (Max pitch 21.5°/sec, max roll 6.5°/sec, max yaw 2°/sec)					
Max	0.51	0.22	−11.7	3.0	3.0
A−3	0.12	0.14	− 1.0	2.4	0
A	0.11	0.08	− 0.5	2.0	0
A+3	0.32	0.19	0	1.9	0
+6	0.21	0.21	1.0	1.5	0
+9	0.10	0.08	3.0	0.5	0
B	−0.18	0.12	7.0	−0.5	0
B+3	−0.35	0.22	9.0	−1.0	0
+6	−0.39	0.12	8.0	−1.5	0
+9	−0.18	0.04	6.0	−1.2	0
C−3	−0.14	0.10	− 5.5	3.0	0
C	0.09	0.02	−10.0	3.0	0
C+3	0.09	0.10	−11.7	3.0	0
D	0	0.11	− 9.0	1.0	0
D+3	0	0.08	− 6.5	0.5	0
+6	0.12	0.05	− 4.0	0.7	0
+9	0.12	0.05	− 1.0	1.2	0

Table AIII. Tabulation of entry and on-course speeds, obstacle 2, 15 June 1971 (see Fig. 29a).

	d_1 = 100 ft		d_2 = 54 ft 9 in.		d_3 = 58 ft 6 in.	
Run	t_1 (sec)	Speed (mph)	t_2 (sec)	Speed (mph)	t_3 (sec)	Speed (mph)
1*	5.1	13	2.1	18	4.0	10
2	4.2	16	2.5	15	2.3	17
3	3.8	18	2.3	16	1.9	21
4	3.4	17.5	2.3	16	2.3	17
5	3.8	18	2.0	18.5	1.8	22
6	3.9	17.5	2.0	18.5	2.0	20
7	3.8	18	2.1	18	1.9	21
8	3.8	18	2.2	17	1.6	25
9	3.0	22.5	1.6	23	1.5	27
10	2.8	24	1.9	20	1.5	27
11	2.5	27	2.0	18.5	1.7	23.5
12	2.8	24	1.9	20	1.1	36
13	2.5	27	1.7	22	1.6	25
14	2.8	24	1.9	20	1.5	27
15	2.1	32	1.1	34	1.6	25
16	2.2	31	1.2	31	1.2	33
17	2.1	32	1.3	29	1.2	33
18*	2.2	31	1.0	37	1.2	33
19	2.2	31	1.1	34	1.1	36
20*	2.2	31	1.1	34	1.0	40

* Dynamic response data were not usable.

Table AIV. Dynamic response data, obstacle 2, 15 June 1971 (see Fig. 29b).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 2 (Max pitch 14°/sec, max roll 4°/sec, max yaw 1-2°/sec)					
Max*	0.51	0.02	–5.0	1.0	2.0
A–3	0	0	0	0	0
A	0	0	0	0	0
A+3	0	0	0	0	0
B	–0.36	0	0	0	0
B+3	–0.28	0	0	0.5	0
+6	0.14	0	–1.5	0.5	0
+9	0.25	0	–3.0	1.0	0
C–3	0	0	3.5	–0.5	0
C	–0.25	0	4.0	–1.0	0
D	–0.23	0	4.0	–1.0	0
D+3	–0.17	0	4.0	–1.0	0
+6	0	0	4.0	–0.5	0
+9	0	0	3.5	–0.5	0
Run 3 (Max pitch 14°/sec, max roll 0°/sec, max yaw 1°/sec)					
Max	–0.42	0.02	–5.5	1.0	3.0
A–3	0	0	0	0.5	1.0
A	0	0	0	0.5	1.0
A+3	0	0	0	0.5	1.0
B	–0.38	0	0	0.5	1.0
B+3	–0.34	0	0	0.5	2.0
+6	–0.36	0	–0.5	0.5	2.0
+9	0	0	–1.0	0.5	2.0
C–3	0.10	0.02	0	0.5	2.0
C	0.42	0.02	1.5	0.5	2.0
D	0	0.02	2.0	0.5	2.0
D+3	–0.18	0	3.5	0.5	2.0
+6	–0.31	0	4.0	0.5	3.0
+9	–0.2	0	4.0	0.5	3.0

*The maximum values seldom appear in the tabulation because they did not occur at a reference position. For instance, in run 2 the maximum heave of 0.51 g was recorded *between* positions A minus 3 ft and A (Fig. 29b).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 4 (Max pitch 16°/sec, max roll 2.5°/sec, max yaw 0°/sec)					
Max	0.41	0.05	–6.0	1.5	0
A–3	0	0	0	0.5	0
A	0	0	0	0.5	0
A+3	0	0	0	0.5	0
B	–0.34	0	0	0.5	0
B+3	–0.36	0.05	0	0.5	0
+6	–0.35	0.05	0	0.5	0
+9	0.09	0.05	–1.5	0.5	0
C–3	0.41	0.1	1.5	0	0
C	0	0	3.0	–0.5	0
D	–0.27	0	3.5	–0.5	0
D+3	–0.22	0	4.0	–0.5	0
+6	–0.21	0	4.5	0	0
+9	–0.08	0	4.0	0	0
Run 5 (Max pitch 15.5°/sec, max roll 4°/sec, max yaw 0°/sec)					
Max	0.4	0.14	–6.0	1.8	0
A–3	0	0	0	1.0	0
A	0	0	0	1.0	0
A+3	0	0	0	1.0	0
B	–0.13	0	0	1.0	0
B+3	–0.39	+0.05	0	1.0	0
+6	–0.36	0.05	0	1.0	0
+9	–0.19	0.05	–0.5	1.0	0
C–3	0.28	0	0	0	0
C	0.4	0	1.0	0	0
D	0	0.14	2.0	–0.5	0
D+3	–0.19	0.03	3.5	–0.5	0
+6	–0.21	0.03	4.0	0	0
+9	–0.29	0.03	4.5	0	0

Table AIV (Cont'd). Dynamic response data, obstacle 2, 15 June 1971 (see Fig. 29b).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 6 (Max pitch 17°/sec, max roll 2°/sec, max yaw 0°/sec)					
Max	0.58	0.14	6.0	1.0	0
A–3	0	0	0	0	0
A	0	0	0	0	0
A+3	0	0	0	0	0
B	–0.28	0	0	0	0
B+3	–0.39	0	0	0	0
+6	–0.33	0	0	0	0
+9	0	0	–1.0	0	0
C–3	0.50	0.14	1.0	0	0
C	0.18	0.11	2.0	0	0
D	0.01	0.09	4.0	0	0
D+3	–0.20	0	4.5	0	0
+6	–0.21	0	4.5	0	0
+9	–0.14	0	5.0	0	0
Run 7 (Max pitch 16.5°/sec, max roll 4°/sec, max yaw 1°/sec)					
Max	0.54	0.22	6.0	1.0	2.0
A–3	0	0	0	0.5	0
A	0	0	0	0.5	0
A+3	0	0	0	0.5	0
B	–0.13	0	0	0.5	0
B+3	–0.36	0	0	0.5	0
+6	–0.35	0	0	0.5	0
+9	–0.20	0	0	0.5	0
C–3	0.36	0.14	0	0	0
C	0.19	0.22	2.0	0	0
D	–0.10	0.20	2.5	0	0
D+3	0	0	4.0	0	0
+6	–0.17	0	4.0	0	0
+9	–0.18	0	5.0	0	0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 8 (Max pitch 14.5°/sec, max roll 3.5°/sec, max yaw 0°/sec)					
Max	0.60	0.18	–6.0	1.0	0
A–3	0	0	0	0	0
A	0	0	0	0	0
A+3	0	0	0	0	0
B	–0.38	0	0	0	0
B+3	–0.38	0	0	0	0
+3	–0.07	0	–0.5	0	0
+9	0.37	0	–1.5	0	0
C–3	0.32	0.09	0.5	0	0
C	–0.15	0.18	2.0	–0.5	0
D	–0.18	0.10	3.0	–0.5	0
D+3	–0.12	0.06	4.0	–0.5	0
+6	–0.20	0.06	4.0	–0.5	0
+9	–0.19	0.06	4.0	–0	0
Run 9 (Max pitch 17°/sec, max roll 6.5°/sec, max yaw 1°/sec)					
Max	0.75	0.5	+5.0	1.5	2.0
A–3	0	0	1.0	0	2.0
A	–0.24	0	1.0	0	2.0
A+3	–0.40	0	1.0	0	2.0
B	–0.39	0	1.0	0	2.0
B+3	–0.29	0	0.5	0	2.0
+6	0	0	0	0.5	2.0
+9	0.42	0	–1.5	0.5	2.0
C–3	0.75	0.50	1.0	0	2.0
C	0	0	2.5	–0.5	2.0
D	–0.31	0	3.5	–1.0	2.0
D+3	0	0.03	5.0	–1.0	2.0
+6	0	0.06	5.0	–1.0	2.0
+9	0	0.1	5.0	–0.5	2.0

Table AIV (Cont'd).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 10 (Max pitch 16.5°/sec, max roll 7.5°/sec, max yaw 1.0°/sec)					
Max	0.85	0.42	–5.0	1.5	+2.0
A–3	0	0	0	0	+2.0
A	0	0	0	0	+2.0
A+3	–0.42	0	0	0	+2.0
B	–0.4	0	0	0	+2.0
B+3	–	0	0	0	+2.0
+6	–	0	–0.5	0	+2.0
+9	–	0	–2.0	0	+2.0
C–3	0.85	0.34	0	0	+2.0
C	0.52	0.34	1.5	–0.5	+2.0
D	0	0.03	2.5	–1.0	+2.0
D+3	–0.34	0.03	3.0	–1.0	+1.0
+6	–0.22	0.0[illegible]	4.0	–1.0	+1.0
+9	–0.39	0.03	4.0	–1.0	+1.0
Run 11 (Max pitch 17°/sec, max roll 4.0°/sec, max yaw 0°/sec)					
Max	0.76	0.30	5.0	1.0	0
A–3	0	0	1.0	0	0
A	–0.38	0	1.0	0	0
A+3	–0.38	0	1.0	0	0
B	–0.39	0	0.5	0	0
B+3	–0.28	0	0	0	0
+6	0.18	0	–1.5	0	0
+9	0.42	0	–2.5	0.5	0
C–3	–0.14	0.15	2.5	0	0
C	–0.31	–0.08	4.0	0	0
D	–0.5	0	5.01	0	0
D+3	–0.42	0	5.0	0	0
+6	–0.23	0	5.0	0.5	0
+9	–0.2	0	4.0	0.5	0
Run 12 (Max pitch 17°/sec, max roll 7°/sec, max yaw 0°/sec)					
Max	0.80	0.3	5.5	–1.5	0
A–3	0	0	+1.0	0	0
A	–0.13	0	+1.0	0	0
A+3	–0.35	0	+1.0	0	0
B	–0.35	0	+1.0	0	0
B+3	–0.31	0	+0.5	0	0
+6	–0.15	0	0	0	0
+9	0.2	0	–1.0	0	0
C–3	0.80	0.05	0	0.5	0
C	0.61	0.3	1.0	0	0
D	0	0.3	1.5	–0.5	0
D+3	–0.38	0.03	3.5	–1.0	0
+6	–0.32	0.11	5.0	–1.0	0
+9	–0.38	0.06	5.5	–1.0	0
Run 13 (Max pitch 18°/sec, max roll 2°/sec, max yaw 7°/sec)					
Max	0.72	0.32	–5.0	1.0	–17.0
A–3	0	0	0	0.5	–17.0
A	0	0	0	0.5	–17.0
A+3	–0.25	0	0	0.5	–17.0
B	–0.52	0	0	0.5	–17.0
B+3	–0.35	0	0	0.5	–17.0
+6	–0.2	0	–0.5	0.5	–17.0
+9	0.14	0	–1.5	0.5	–17.0
C–3	0.72	0.32	0	0.5	–17.0
C	0.28	0.32	1.5	0.5	–17.0
D	–0.35	0.21	2.5	0.5	–17.0
D+3	–0.35	–0.06	4.5	0.5	–17.0
+6	–0.55	0.21	4.5	0.5	–17.0
+9	–0.35	0.08	4.5	0	–17.0

Table AIV (Cont'd). Dynamic response data, obstacle 2, 15 June 1971 (see Fig. 29b).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 14 (Max pitch 17°/sec, max roll 0°/sec, max yaw 4°/sec)					
Max	0.61	0.3	5.5	1.0	8.0
A–3	0	0	0.5	0	8.0
A	0	0	0.5	0	8.0
A+3	0	0	0.5	0	8.0
B	0	0	0.5	0	8.0
B+3	–0.39	0	0.5	0	8.0
+6	–0.39	0	0.5	0	8.0
+9	–0.32	0	0	0	8.0
C–3	0.54	0.2	0	0.5	8.0
C	0.61	0.3	1.0	0.5	8.0
D	0.25	0.3	2.0	0	8.0
D+3	–0.12	0.03	3.0	0	8.0
+6	–0.26	0.03	5.0	0	8.0
+9	–0.48	0.03	5.0	0	8.0
Run 15 (Max pitch 12°/sec, max roll 3.5°/sec, max yaw 3°/sec)					
Max	0.80	0.55	–3.5	1.0	12.0
A–3	0	0	0.5	0	6.0
A	0	0	0.5	0	6.0
A+3	0	0	0.5	0	7.0
B	–0.31	0	0.5	0	7.0
B+3	–0.31	0	0.5	0	7.0
+6	–0.32	0	0.5	0	8.0
C–3	+0.80	0.55	–2.0	0.5	10.0
C	0	0.40	–1.5	0.5	10.0
D	–0.38	0.07	–1.0	0	10.0
D+3	–0.18	0.08	–0.5	0	10.0
+6	–0.05	0.09	0	–0.5	10.0
+9	–0.27	0.10	1.0	–0.5	10.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 16 (Max pitch 14°/sec, max roll 0°/sec, max yaw 0°/sec)					
Max	0.65	–	–4.5	1.0	0
A–3	0	0	0	0	0
A	0	0	0	0	0
A+3	0	0	0	0	0
B	–25.0	0	0	0	0
B+3	–42.0	0	0	0	0
+6	– 0.3	0	0	0	0
+9	0.65	0	0	0	0
C–3	– 0.30	–	–3.0	0.5	0
C	–	–	–2.5	0.5	0
D	–	–	–2.0	0	0
D+3	–	–	–0.5	0	0
+6	–	–	0	–0.5	0
+9	–	–	0.5	–0.5	0
Run 17 (Max pitch 14°/sec, max roll 3°/sec, max yaw 4°/sec)					
Max	0.82	0.4	4.0	1.0	15.0
A–3	0	0	1.0	–0.5	12.0
A	0	0	1.0	–0.5	12.0
A+3	– 0.2	0	1.0	–0.5	12.0
B	– 0.35	0	0.5	0	12.0
B+3	– 0.5	0	0.5	0	12.0
+6	– 0.5	0	0	0	12.0
+9	– 0.4	0	0	0	12.0
C–3	0.82	0.05	–3.0	0	15.0
C	0.3	0.05	–2.5	0	15.0
D	0	0.4	–2.0	0	15.0
D+3	– 0.15	0.18	–1.5	0	15.0
+6	– 0.2	0	–1.0	–0.5	15.0
+9	– 0.3	0.18	0	–0.5	15.0

Table AIV (Cont'd).

Posn	*Heave (g)* *+ = up*	*Surge (g)* *+ = ahead*	*Pitch (deg)* *+ = bow up*	*Roll (deg)* *+ = stbd*	*Yaw (deg)* *+ = east*
Run 19 (Max pitch 10.5°/sec, max roll 5°/sec, max yaw 8°/sec)					
Max	0.63	0.63	–4.5	1.0	20.0
A–3	–0.40	0	0	0	15.0
A	–0.45	0	0	0	15.0
A+3	–0.45	0	0	0	15.0
B	–0.40	0	0	0	16.0
B+3	–0.25	0	0	0	16.0
+6	0.15	0	–0.5	0	16.0
+9	0.45	0	–1.5	0	17.0
C–3	0	0.63	–1.5	0	17.0
C	–0.10	0	–0.5	0	20.0
D	–0.10	0	0	0	20.0
D+3	–0.4	0.36	0.5	–0.5	20.0
+6	–0.5	0.3	0.5	–0.5	20.0
+9	0	0	0	–0.5	20.0

Table AV. Tabulation of entry and on-course speeds, obstacle 3, 15 June 1971 (see Fig. 29a).

	d_1 100 ft		d_2 147 ft 6 in.		d_3 187 ft	
Run	t_1 (sec)	Speed (mph)	t_2 (sec)	Speed (mph)	t_3 (sec)	Speed (mph)
1	4.4	15.5	5.5	20	6.7	16.5
2	3.7	18	5.6	20	6.1	18
3	4.1	16.5	5.8	19	6.1	18
4	3.5	19.5	3.4	32.5	6.3	20
5	3.2	21	4.7	23.5	6.1	18
6	3.8	18	4.9	23	6.7	16.5
7	3.5	19.5	4.8	23	5.7	22
8	3.7	18.5	5.1	22	5.6	23
9	3.7	18.5	4.8	23	5.7	22
10	3.4	20	4.5	24.5	6.3	20
11	2.5	27	3.6	31	4.5	28
12	2.7	25	3.2	34.5	4.1	31
13	2.3	30	3.4	32.5	4.5	28
14	2.5	27	3.3	33.5	4.4	29
15	2.4	28	3.4	32.5	4.2	30
16	2.2	31	3.7	30	4.1	31
17	1.8	38	2.4	46	3.0	42
18*	2.0	34	2.5	44	3.1	41
19	2.0	34	2.3	48	3.1	41
20	1.9	35	2.3	48	3.0	42
21	1.8	38	2.4	46	3.0	42
22	2.0	34	2.3	48	3.3	39

* Dynamic response data were not usable.

Table AVI Dynamic response data, obstacle 3, 15 June 1971 (see Fig. 29b).

Run 1 (Max pitch 14°/sec, max roll 6.5°/sec, max yaw 8°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max*	0.62	0.29	–11.5	–3.5	25.0
A–3	–	–	–	0	10.0
A	–	–	–	–0.5	11.0
A+3	0.47	–	– 1.0	–1.0	12.0
B	0.33	–	– 3.5	–1.0	13.0
B+3	0.62	–	– 6.5	–0.5	14.0
+6	0.09	–	– 9.5	0	15.0
+9	0.10	–	–11.5	0.5	16.0
C–3	0.12	0.15	5.0	–2.0	25.0
C	–0.15	0.17	6.0	–2.5	25.0
C+3	–0.40	0.2	7.5	–3.5	25.0
D	–0.44	0.29	8.0	–3.5	25.0
D+3	–0.35	0.18	7.0	–3.5	25.0
+6	–0.19	0.05	5.5	–3.5	25.0
+9	–0.08	0	3.5	–3.0	25.0

Run 2 (Max pitch 30°/sec, max roll 6.2°/sec, max yaw 8°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	–0.68	0.20	–12.0	–3.0	38.0
A–3	–0.31	0.04	1.0	–0.3	23.0
A	–0.68	0.10	1.5	–0.5	23.0
A+3	–0.57	0.19	0.5	–0.5	24.0
B	–0.45	0.11	– 2.5	–1.0	25.0
B+3	0.51	0.02	– 5.5	–0.5	26.0
+6	0.07	0.14	– 9.0	0	27.0
+9	0.08	0.17	–11.0	1.0	28.0
C–3	0.02	0.11	3.0	–1.5	30.0
C	–0.02	0.13	4.5	–2.2	30.0
C+3	–0.10	0.16	6.0	–3.0	29.0
D	–0.18	0.15	7.5	–3.0	29.0
D+3	–0.34	0.19	8.0	–3.0	29.0
+6	–0.3	0.19	7.5	–3.0	28.0
+9	–0.2	0.09	6.0	–3.0	28.0

*The maximum values seldom appear in the tabulation because they did not occur at a reference position. For instance, in run 1 the maximum heave of 0.62 g was recorded *between* positions A minus 3 ft and A (Fig. 29b).

Run 3 (Max pitch 26°/sec, max roll 6.5°, max yaw 6°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.58	0.22	–11.5	–3.5	15.0
A–3	–0.21	0.06	0	0	13.0
A	–0.58	0.07	0.5	–0.5	13.0
A+3	–0.58	0.18	0	–0.8	12.0
B	–0.35	0.22	– 2.5	–1.0	11.0
B+3	–0.13	0.03	– 5.5	–1.0	11.0
+6	0	0.04	– 8.5	–0.5	10.0
+9	0	0.14	–10.5	0	10.0
C–3	0	0.14	5.0	–2.5	2.0
C	–0.12	0.20	6.5	–3.0	2.0
C+3	–0.20	0.21	8.0	–3.5	3.0
D	–0.29	0.21	8.0	–3.5	3.0
D+3	–0.29	0.18	7.5	–3.5	3.0
+6	–0.14	0.07	6.5	–3.5	4.0
+9	–0.07	0	5.0	–3.0	5.0

Run 4 (Max pitch 33°/sec, max roll 10.5°/sec, max yaw 9°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.7	0.20	–12.0	–4.0	24.0
A–3	–0.26	0.07	0.5	–0.5	15.0
A	–0.59	0.11	1.0	–0.5	15.0
A+3	–0.56	0.12	0.5	–0.5	16.0
B	–0.42	0.20	– 1.5	–0.5	16.0
B+3	–0.27	0.11	– 9.0	–0.5	17.0
+6	0.28	0.05	– 6.5	0	18.0
+9	0.21	0.08	– 9.5	0.5	19.0
C–3	0.20	0.19	4.0	–2.0	24.0
C	–0.07	0.18	5.5	–3.0	24.0
C+3	–0.08	0.15	6.5	–4.0	24.0
D	–0.46	0.07	6.5	–4.0	24.0
D+3	–0.37	0.05	6.0	–4.0	24.0
+6	–0.11	0.02	4.0	–3.5	24.0
+9	–0.1	0	2.0	–2.5	24.0

Table AVI (Cont'd). Dynamic response data, obstacle 3, 15 June 1971 (see Fig. 29b).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 5 (Max pitch 31°/sec, max roll 8.5°/sec, max yaw 9°/sec)					
Max	0.69	0.33	−12.0	−5.0	−10.0
A−3	−0.62	0.08	0.5	−0.5	− 2.0
A	−0.55	0.10	0	−0.5	− 2.0
A+3	−0.35	0.15	− 2.5	−0.5	− 2.0
B	0	0.03	− 5.0	0	− 2.0
B+3	0.18	0.08	− 7.5	0.8	− 2.0
+6	0.17	0.12	−10.0	1.5	− 2.0
+9	0.19	0.15	−11.5	2.5	− 2.0
C−3	0.20	0.18	1.5	−2.0	−10.0
C	0.17	0.14	2.5	−2.5	−10.0
C+3	0	0.14	4.0	−3.5	−10.0
D	−0.19	0.18	5.0	−4.5	−10.0
D+3	−0.16	0.12	5.5	−4.8	−10.0
+6	−0.29	0.19	6.0	−5.0	−10.0
+9	−0.29	0.12	5.5	−4.5	−10.0
Run 6 (Max pitch 32°/sec, max roll 11°/sec, max yaw 8°/sec)					
Max	0.9	0.42	−12.0	−6.5	24.0
A−3	0	0	0.5	0	13.0
A	0	0.02	0.5	−0.5	13.0
A+3	−0.46	0.08	0.5	−1.0	13.0
B	−0.59	0.10	0.5	−1.0	14.0
B+3	−0.5	0.10	− 0.5	−1.0	14.0
+6	−0.32	0.13	− 2.5	−0.5	15.0
+9	0	0.07	− 4.5	0	15.0
C−3	0.15	0.15	2.0	−3.5	22.0
C	0.04	0.15	3.0	−4.5	22.0
C+3	−0.12	0.16	4.0	−6.0	23.0
D	−0.17	0.11	5.0	−6.5	23.0
D+3	−0.19	0.13	5.5	−6.5	23.0
+6	−0.7	0.14	5.0	−6.5	22.0
+9	−0.17	0.09	4.0	−6.0	22.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 7 (Max pitch 25°/sec, max roll 12.2°/sec, max yaw 4°/sec)					
Max	0.66	0.33	−12.0	−7.0	13.0
A−3	−0.52	0.06	0.5	−0.2	0
A	−0.62	0.10	0.3	−0.5	0
A+3	−0.51	0.19	− 0.5	−0.5	0
B	−0.36	0.2	− 3.5	−0.5	0
B+3	0.13	0	− 6.0	0	0
+6	0.16	0.08	− 8.5	1.0	0
+9	0.16	0.14	−11.0	1.5	0
C−3	0.12	0.20	2.0	−3.0	10.0
C	0.15	0.11	3.5	−4.5	10.0
C+3	−0.1	0.15	4.5	−5.5	11.0
D	−0.18	0.14	5.2	−6.5	11.0
D+3	−0.43	0.17	5.5	−7.0	12.0
+6	−0.39	0.25	5.0	−6.8	12.0
+9	−0.19	−	3.5	−5.5	13.0
Run 8 (Max pitch 30°/sec, max roll 10°/sec, max yaw 4°/sec)					
Max	0.62	0.22	−11.5	−4.3	17.0
A−3	0	0	0.3	0	12.0
A	−0.47	0.03	0.5	0	12.0
A+3	−0.6	0.12	0.5	0	12.0
B	−0.46	0.18	− 0.7	0	12.0
B+3	−0.28	0.11	− 3.5	0	13.0
+6	0.45	0	− 6.5	0.4	13.0
+9	0	0.10	− 9.0	1.5	13.0
C−3	0.15	0.18	2.5	−1.5	16.0
C	0.20	0.10	3.5	−2.0	16.0
C+3	0.12	0.11	5.0	−2.5	16.0
D	−0.09	0.24	6.5	−3.5	16.0
D+3	−0.10	0.11	7.5	−4.0	16.0
+6	−0.45	0.26	7.5	−4.3	16.0
+9	−0.36	0.09	6.5	−4.0	16.0

Table AVI (Cont'd).

Run 9 (Max pitch 34°/sec, max roll 7.5°/sec, max yaw 2°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.7	0.24	−12.3	−4.5	−8.0
A−3	−0.53	0.07	0	−1.0	−6.0
A	−0.54	0.10	0	−1.0	−6.0
A+3	−0.44	0.16	− 1.5	−1.0	−7.0
B	−0.29	0.09	− 4.5	−0.5	−7.0
B+3	0.44	−0.09	− 7.0	0	−7.0
+6	0.20	0.09	−10.0	1.0	−8.0
+9	0.21	0.15	−11.5	2.0	−8.0
C−3	0.11	0.18	2.0	−2.0	−7.0
C	0.11	0.11	3.5	−3.0	−7.0
C+3	−0.09	0.18	5.0	−4.0	−7.0
D	−0.13	0.17	6.5	−4.5	−7.0
D+3	−0.32	0.22	7.0	−4.5	−7.0
+6	−0.41	0.16	6.0	−4.0	−7.0
+9	−0.25	0.06	4.5	−3.5	−7.0

Run 10 (Max pitch 35°/sec, max roll 9.5°/sec, max yaw 2°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.66	0.48	−12.0	−3.3	4.0
A−3	0	0	0.5	+0.5	3.0
A	−0.5	0.09	0.7	0	3.0
A+3	−0.59	0.17	0.5	0	3.0
B	−0.47	0.10	− 0.5	−0.5	2.0
B+3	−0.32	0.16	− 2.5	0	2.0
+6	0	0.12	− 5.0	0.5	2.0
+9	0.19	0.08	− 7.5	1.0	2.0
C−3	0.31	0.23	0.5	0	0
C	0.21	0.22	1.5	−0.5	0
C+3	0.13	0.21	2.5	−1.0	0
D	0.15	0	4.0	−1.5	0
D+3	0	0.18	5.5	−2.0	0
+6	−0.44	0.48	7.0	−3.0	0
+9	−0.45	0.28	7.0	−3.2	0

Run 11 (Max pitch 27°/sec, max roll 12°/sec, max yaw 1.0°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.9	0.41	−8.0	3.5	−5.0
A−3	−0.6	0.12	0.5	−0.3	−2.0
A	−0.6	0.13	0	−0.3	−2.0
A+3	−0.3	0.13	−1.0	−0.5	−2.0
B	−0.59	0.13	−2.5	−0.5	−2.0
B+3	−0.2	0	−9.5	−0.2	−2.0
+6	0.23	0	−6.0	0	−3.0
+9	0.28	0.04	−7.0	1.0	−4.0
C−3	0.13	0.31	1.5	0	−4.0
C	+0.08	0.29	2.5	−0.5	−4.0
C+3	−0.29	0.28	4.0	−1.0	−4.0
D	−0.43	0.28	5.5	−1.5	−4.0
D+3	−0.15	0.26	5.5	−2.0	−4.0
+6	−0.48	0.25	6.0	−2.5	−4.0
+9	−0.58	0.15	6.0	−2.5	−4.0

Run 12 (Max pitch 31°/sec, max roll 9°/sec, max yaw 0°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	1.0	0.33	−8.5	−4.0	2.0
A−3	−0.39	0.09	1.0	0	2.0
A	−0.69	0.11	1.0	0	2.0
A+3	−0.66	0.13	0.5	−0.5	2.0
B	−0.65	0.14	−1.0	−0.5	2.0
B+3	−0.65	0.15	−2.2	−0.3	2.0
+6	−0.68	0.13	−3.5	0	2.0
+9	−0.1	0	−5.5	0.3	2.0
C−3	0.21	0.31	1.5	−0.5	0
C	0	0.28	3.0	−1.0	0
C+3	0	0.05	4.0	−2.0	0
D	−0.21	0.47	5.0	−2.9	0
D+3	−0.33	0.37	6.0	−3.3	0
+6	−0.43	0.21	6.5	−4.0	0
+9	−0.54	0.21	4.5	−3.9	0

Table AVI (Cont'd). Dynamic response data, obstacle 3, 15 June 1971 (see Fig. 29b).

Run 13 (Max pitch 25°/sec, max roll 30°/sec, max yaw 0°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	1.0	0.45	–8.5	–	0
A–3	–0.72	0.11	0.5	–0.5	0
A	–0.71	0.12	0	–0.5	0
A+3	–0.78	0.12	–2.5	–0.5	0
B	–0.30	0.03	–4.2	–0.5	0
B+3	0.12	0	–5.5	0	0
+6	0.24	0	–7.0	0.5	0
+9	0.45	0.07	–8.0	1.0	0
C–3	0.49	0.30	0.5	–	0
C	0.27	0.27	2.0	–	0
C+3	0.11	0.21	2.9	–	0
D	–0.15	0.14	4.5	–	0
D+3	–0.20	0.45	6.2	–	0
+6	–0.28	0.40	6.0	–	0
+9	–0.34	0.16	7.0	–	0

Run 14 (Max pitch 30°/sec, max roll 7.5°/sec, max yaw 3°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.84	0.4	–8.5	–4.0	–2.0
A–3	–0.53	0.03	1.0	0	0
A	–0.64	0.06	1.0	0	0
A+3	–0.62	0.09	0.5	0	0
B	–0.55	0.10	0	0	0
B+3	–0.46	0.11	–2.0	0	0
+6	–0.32	0.09	–3.5	0	0
+9	0.22	0.08	–5.0	0.5	0
C–3	0.55	0.3	0.8	0	0
C	0.27	0.26	1.5	0	0
C+3	0.16	0.16	2.5	–1.0	0
D	0	0.4	3.7	–1.5	0
D+3	–0.11	0.4	4.5	–2.3	0
+6	–0.25	0.27	5.6	–3.0	0
+9	–0.4	0.26	6.7	–3.5	0

Run 15 (Max pitch 25°/sec, max roll 12°/sec, max yaw 1°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.86	0.5	–8.0	3.4	2.0
A–3	–0.50	0.05	1.0	–0.2	2.0
A	–0.67	0.09	1.0	–0.5	2.0
A+3	–0.61	0.09	0.5	–0.8	2.0
B	–0.57	0.13	–1.0	–0.8	2.0
B+3	–0.73	0	–2.5	–0.8	2.0
+6	0.21	0	–3.5	–0.3	2.0
+9	0.10	0	–6.0	+0.5	2.0
C–3	0.28	0.31	1.0	0	0
C	0.17	0.29	2.0	–0.2	0
C+3	–0.30	0.21	3.0	–1.0	0
D	–0.31	0.12	4.5	–1.5	0
D+3	–0.32	0.39	5.5	–2.0	0
+6	–0.28	0.5	6.0	–2.5	0
+9	–0.44	0.28	6.5	–3.0	0

Run 16 (Max pitch 27°/sec, max roll 11°/sec, max yaw 3°/sec)

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Max	0.98	0.39	–8.0	–4.5	5.0
A–3	0	0	0.5	–0.5	0
A	–0.70	0.10	0.7	–0.5	0
A+3	–0.69	0.10	0.8	–0.5	0
B	–0.61	0.15	0.4	–0.5	0
B+3	–0.63	0.14	–1.0	–0.5	0
+6	–0.71	0.09	–2.0	–0.5	0
+9	–0.24	0	–3.5	–0.5	0
C–3	0.09	0.21	2.5	–1.5	2.0
C	0.05	0.14	3.5	–2.5	2.0
C+3	0.03	0.39	4.0	–3.0	2.0
D	–0.09	0.25	5.0	–3.5	2.0
D+3	–0.2	0.19	6.0	–4.0	2.0
+6	–0.44	0.18	6.0	–4.2	3.0
+9	–0.55	0.17	5.0	–4.5	3.0

Table AVI (Cont'd).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 17 (Max pitch 18°/sec, max roll 12°/sec, max yaw 3°/sec)					
Max	1.5	0.26	–5.5	–3.5	5.0
A–3	–0.68	0	0.5	–1.0	0
A	–0.64	0	0.5	–1.5	0
A+3	–0.65	0	0	–2.0	0
B	–0.69	0	–0.5	–2.3	0
B+3	–0.71	0	–1.0	–2.5	0
+6	–0.76	0	–1.5	–2.0	0
+9	–0.80	0	–2.2	–1.5	0
C–3	0.55	0.19	1.0	–1.5	5.0
C	0.25	0.21	1.5	–1.7	5.0
C+3	–0.08	0.24	2.0	–2.0	5.0
D	–0.32	0.25	3.0	–2.5	5.0
D+3	–0.48	0.24	3.5	–3.0	5.0
+6	–0.50	0.26	3.5	–3.5	5.0
+9	–0.58	0.25	3.5	–3.5	5.0
Run 18 (Max pitch 14.5°/sec, max roll 13°/sec, max yaw 1.0°/sec)					
Max	1.42	0.46	–6.0	–4.0	10.0
A–3			0.8	–1.6	2.0
A			0.5	–2.0	2.0
A+3	Interference		–0.5	–2.0	2.0
B			–1.3	–2.3	2.0
B+3			–2.0	–2.4	2.0
+6			–3.0	–2.4	2.0
+9			–4.5	–1.5	2.0
C–3			4.0	–3.5	8.0
C			3.8	–3.5	8.0
C+3			3.5	–4.0	8.0
D			3.3	–3.8	8.0
D+3			3.0	–3.5	8.0
+6			1.5	–2.5	8.0
+9			0	–1.5	8.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 19 (Max pitch 19°/sec, max roll 11°/sec, max yaw 2°/sec)					
Max	1.42	0.48	–4.2	–3.0	– 5.0
A–3			1.0		– 3.0
A			1.0		– 3.0
A+3			0		– 3.0
B			–1.0		– 3.0
B+3			–1.5		– 3.0
+6			–2.5		– 3.0
+9			–4.0		– 3.0
C–3			3.5	–2.2	– 5.0
C			4.2	–2.8	– 5.0
C+3			4.0	–3.0	– 5.0
D			3.8	–3.0	– 5.0
D+3			3.5	–3.0	– 5.0
+6			3.0	–2.8	– 5.0
+9			2.5	–2.5	– 5.0
Run 20 (Max pitch 20.5°/sec, max roll 12.5°/sec, max yaw 8°/sec)					
Max	1.48	0.6	–5.5	–2.5	10.0
A–3			1.0	–1.2	+ 5.0
A			–0.3	–1.5	+ 5.0
A+3			–0.8	–1.5	+ 5.0
B			–1.5	–1.6	+ 5.0
B+3			–2.5	–1.5	5.0
+6			–3.5	–1.2	5.0
+9			–4.5	–1.0	5.0
C–3			1.5	–0.6	7.0
C			2.5	–1.1	7.0
C+3			3.5	–1.5	8.0
D			3.9	–1.7	8.0
D+3			4.0	–1.8	9.0
+6			4.0	–1.9	9.0
+9			3.7	–2.2	10.0

Table AVI (Cont'd). Dynamic response data, obstacle 3, 15 June 1971 (see Fig. 29b).

Posn	*Heave (g) + = up*	*Surge (g) + = ahead*	*Pitch (deg) + = bow up*	*Roll (deg) + = stbd*	*Yaw (deg) + = east*
Run 21 (Max pitch 19°/sec, max roll 9.5°/sec, max yaw 3°/sec)					
Max	1.3	0.55	–5.0	–3.5	14.0
A–3	–0.65	0.12	0.5	0	0
A	–0.65	0.10	–0.5	–0.5	0
A+3	–0.65	0	–1.5	–0.5	0
B	–0.6	0.10	–2.5	–0.8	0
B+3	–0.4	0.10	–3.5	–0.9	0
+6	0	0.08	–4.0	–0.5	0
+9	0.65	0.05	–4.5	–0.5	0
C–3	0.35	0.35	1.5	–1.5	11.0
C	0	0.34	2.0	–1.7	11.0
C+3	–0.2	0.3	2.5	–2.0	11.0
D	–0.3	0.3	2.8	–2.3	11.0
D+3	–0.35	0.25	3.0	–2.7	11.0
+6	–0.4	0.15	3.5	–3.0	11.0
+9	–0.5	0.10	3.0	–3.3	11.0

Table AVII. Tabulation of entry and on-course speeds, obstacle 4, 15 June 1971 (see Fig. 31b).

	$d_1 = 100$ ft		$d_2 = 40$ ft		$d_3 = 57$ ft	
Run	t_1 (sec)	Speed (mph)	t_2 (sec)	Speed (mph)	t_3 (sec)	Speed (mph)
1	3.5	19.5	2.4	12.5	2.7	14
2	3.8	18	2.5	12	1.9	20
3	3.6	19	1.5	20	2.1	18.5
4	3.1	22	2.3	13	2.2	17.5
5	2.8	24	1.7	17.5	2.0	19
6	3.4	20	1.5	20	1.9	20
7	3.1	22	1.9	16	1.5	26
8	3.1	22	1.4	21	1.9	20
9	3.1	22	1.6	19	1.8	21.5
10	3.1	22	1.7	17.5	1.8	21.5
11	2.4	28	0.8	37	1.8	21.5
12	2.4	28	1.2	25	1.3	30
13	2.5	27	1.3	23	1.1	35
14	2.3	30	1.1	27	1.4	27
15	2.2	31	1.0	30	1.6	24
16	2.2	31	1.1	27	1.3	30
17	3.5	19.5	2.3	13	2.2	17.5
18	3.3	21	2.6	11.5	2.1	18.5
19	3.7	18	1.9	16	2.5	15.5
20	3.5	19.5	2.0	15	2.5	15.5

Table AVIII. Dynamic response data, obstacle 4, 15 June 1971 (see Fig. 31).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 1 (Max pitch 9°/sec, max roll 13°/sec, max yaw 5°/sec)					
Max*	–0.38	0.12	-3.3-6.5	+2.5-5.5	35.0
A–3	0	0	–1.0	0	25.0
A	0	0	–0.5	0	26.0
A+3	0	0.05	0	–0.5	27.0
B	0	0.06	0	0	28.0
B+3	–0.07	0.08	1.0	0	29.0
+6	–0.12	0.08	2.0	0	30.0
+9	–0.22	0.06	3.0	0	30.0
C–3	0.08	0.15	–6.0	–2.0	30.0
C	0	0.17	–6.5	–1.5	30.0
D	–0.05	0.17	6.5	–2.0	29.0
D–3	0	0.17	–6.0	–2.0	28.0
+6	0	0.17	–5.5	–2.0	27.0
+9	0	0.16	–4.5	–2.0	26.0
Run 2 (Max pitch 17°/sec, max roll 7°/sec, max yaw 10°/sec)					
Max	–0.42	0.16	–8.5	3.5	24.0
A–3	0	0	–1.5	0	20.0
A	0	0	–1.0	0	21.0
A+3	0	0.02	0	0	22.0
B	0.05	0.02	0	0	23.0
B+3	0.05	0.12	0	0	23.0
+6	0	0.16	1.0	0	24.0
+9	0	0.06	2.0	–1.0	24.0
C–3	–0.15	0	–2.0	2.0	18.0
C	0.54	0	–14.0	3.0	18.0
D	0.22	0.1	–6.0	3.5	17.0
D–3	0.12	0.1	–7.5	4.0	17.0
+6	0	0.1	–8.0	3.5	17.0
+9	0.05	0.1	–8.0	3.0	17.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 3 (Max pitch 17°/sec, max roll 5.5°/sec, max yaw 8°/sec)					
Max	0.5	0.2	–9.0	3.5	25.0
A–3	0	0	–1.0	0	23.0
A	0.14	0	–0.5	0	23.0
A+3	0.28	0	0	0	23.0
B	0	0.2	0.5	0	24.0
B+3	0	0	1.0	0	24.0
+6	0	0.08	2.0	–0.5	25.0
+9	–0.06	0.08	2.5	–1.0	25.0
C–3	–0.48	0.14	2.0	0.5	25.0
C	–0.4	0.10	1.0	1.0	25.0
D	–0.3	0.14	0	1.0	25.0
D–3	0	0.05	–2.0	1.5	24.0
+6	0.5	0.10	–5.0	2.5	24.0
+9	0	0.14	–6.0	3.0	23.0
Run 4 (Max pitch 10°/sec, max roll 15°/sec, max yaw 10°/sec)					
Max	–0.48	0.2	–6.5	–6.5	37.0
A–3	0	0	–1.0	0	24.0
A	0	0	–1.0	0	26.0
A+3	0.03	0	–0.5	0	27.0
B	0.15	0	0.2	0	29.0
B+3	0	0.2	0	0	30.0
+6	0	0.11	1.0	0	31.0
+9	0	0	2.0	0	32.0
C–3	–0.3	0.14	–2.0	–6.5	35.0
C	–0.08	0.13	–3.0	–5.5	34.0
D	0.05	0.12	–4.0	–4.5	33.0
D–3	0.05	0.11	–5.0	–4.0	32.0
+6	0.05	0.10	–6.0	–3.5	31.0
+9	0	0.09	–6.5	–3.5	30.0

*The maximum values seldom appear in the tabulation because they did not occur at a reference position. For instance, in run 1 the maximum heave of –0.38 g was recorded *between* positions A minus 3 ft and A (Fig. 31).

Table AVIII (Cont'd).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 5 (Max pitch 18°/sec, max roll 6.5°/sec, max yaw 6°/sec)					
Max	0.53	0.2	−8.5	3.0	22.0
A−3	0	0	−1.0	−1.0	8.0
A	0	0	−1.0	−0.5	9.0
A+3	0	0	−1.0	0	10.0
B	0	0	−0.5	0	11.0
B+3	0.05	0	0	+0.5	12.0
+6	0.32	0.07	0	−0.5	13.0
+9	0.1	0.18	−0.5	0	15.0
C−3	−0.39	0.1	1.0	0.5	22.0
C	−0.5	0.1	2.0	0.5	22.0
D	−0.51	0.1	1.5	0.5	22.0
D+3	−0.32	0.1	0	1.0	22.0
+6	−0.38	0.05	−1.0	1.0	22.0
+9	0	0	−3.0	1.5	22.0
Run 6* (Max pitch 15°/sec, max roll 5.5°/sec, max yaw 6°/sec)					
Max	0.52	0.2	−8.5	3.0	18.0
A−3	−0.03	0	−1.5	−1.0	15.0
A	0	0	−1.0	−0.5	15.0
A+3	0	0	−0.5	0	16.0
B	0.13	0	0	0	16.0
B+3	0.32	0	0.5	0	17.0
+6	0	0.2	1.0	0	18.0
+9	0	0.1	1.5	−0.5	18.0
C−3	−0.52	0.1	1.5	0.5	17.0
C	−0.49	0.11	1.5	0.5	17.0
D	−0.5	0.13	1.0	0.5	16.0
D+3	−0.48	0.15	0	1.0	16.0
+6	−0.18	0	−2.0	1.5	15.0
+9	−0.28	0	−5.0	2.0	14.0

*Rerun

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 7 (Max pitch 19°/sec, max roll 8°/sec, max yaw 12°/sec)					
Max	−0.52	0.15	−8.0	3.0	33.0
A−3	0	0	−2.0	0.5	18.0
A	0	0	−1.5	0.5	20.0
A+3	0	0	−1.0	0.5	21.0
B	0	0	0	0	22.0
B+3	0.24	0	0.5	0	23.0
+6	0.1	0.15	1.0	0	24.0
+9	0	0.06	2.0	0	25.0
C−3	−0.52	0.06	1.0	0	33.0
C	−0.52	0.06	−0.5	0	33.0
D	−0.3	0.06	−1.0	0.5	33.0
D+3	0	0.1	−3.5	1.0	33.0
+6	0.22	0	−5.5	1.5	33.0
+9	0	0.1	−7.5	2.0	32.0
Run 8 (Max pitch 18°/sec, max roll 9.5°/sec, max yaw 9°/sec)					
Max	0.48	0.16	−8.0	3.5	25.0
A−3	0	0	−1.0	0	18.0
A	0	0	−1.0	0	19.0
A+3	0	0	−1.0	0	20.0
B	0	0	−0.5	0	21.0
B+3	0.32	0	0	0	22.0
+6	0.28	0.15	0.5	0	23.0
+9	0	0.07	1.0	0	24.0
C−3	0.48	0.09	1.0	0.5	26.0
C	0.48	0.11	2.0	0.5	26.0
D	0.47	0.13	1.5	0.5	26.0
D+3	0.43	0.14	0.5	0.5	26.0
+6	0.34	0.15	−1.0	1.0	26.0
+9	0	0.16	−3.0	1.0	26.0

Table AVIII (Cont'd). Dynamic response data, obstacle 4, 15 June 1971 (see Fig. 31).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 9 (Max pitch 18.5°/sec, max roll 8.5°/sec, max yaw 6°/sec)					
Max	0.48	0.15	−8.5	2.5	15.0
A−3	0	0	−1.5	1.0	2.0
A	−0.06	0	−1.5	0.5	2.0
A+3	0	0	−1.5	0	3.0
B	0	0	−1.0	0	4.0
B+3	0.11	0	−0.5	0	4.0
+6	0.22	0	0	0	5.0
+9	0.22	0.14	0.5	0	5.0
C−3	−0.44	0.05	0.5	0.5	13.0
C	−0.45	0.05	1.5	0	13.0
D	−0.43	0.05	1.0	0	13.0
D+3	−0.42	0.05	0	0.5	13.0
+6	−0.18	0.05	−2.0	1.0	13.0
+9	0.35	−0.14	−4.5	1.5	14.0
Run 10 (Max pitch 21°/sec, max roll 8.5°/sec, max yaw 12°/sec)					
Max	−0.53	0.15	9.0	3.0	43.0
A−3	−0.15	0	−1.5	0	22.0
A	0	0	−1.5	0	24.0
A+3	0	0	−1.0	0.5	26.0
B	0.07	0	−0.5	0.5	28.0
B+3	0.03	0	0	0.5	29.0
+6	0.20	0.15	0.5	0	31.0
+9	0.14	+0.03	1.0	0	32.0
C−3	−0.10	0.08	0	1.0	43.0
C	−0.53	0.08	1.5	1.0	43.0
D	−0.53	0.08	2.0	0.5	43.0
D+3	−0.5	0.08	1.5	0.5	43.0
+6	−0.39	0.08	0	1.0	43.0
+9	−0.22	0.08	−2.0	1.5	42.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 11 (Max pitch 12°/sec, max roll 4°/sec, max yaw 4°/sec)					
Max	0.65	0.2	−8.5	−2.5	17.0
A−3	−0.18	0	−1.5	−0.5	8.0
A	0	0	−1.5	0	8.0
A+3	0	0.05	−1.5	0	9.0
B	0.18	0.10	−1.0	0	9.0
B+3	0.65	0.15	−0.5	0	10.0
+6	0.34	0.20	0	0	10.0
+9	0.10	0.10	1.0	0	10.0
C−3	−0.49	0.06	−2.0	−1.5	15.0
C	−0.2	0.06	−2.0	−1.5	15.0
D	−0.15	0.06	−3.0	−1.5	15.0
D+3	0	0.06	−4.0	−1.5	15.0
+6	0.22	0.05	−5.0	−1.5	15.0
+9	0.09	0.05	−6.0	−1.5	15.0
Run 12 (Max pitch 14°/sec, max roll 5°/sec, max yaw 6°/sec)					
Max	0.35	0.19	−7.5	−1.5	8.0
A−3	−0.04	0	−1.5	−1.0	6.0
A	−0.1	0	−2.0	−1.0	6.0
A+3	−0.13	0	−2.0	−1.0	6.0
B	−0.1	0	−2.0	−0.5	6.0
B+3	0	0.05	−1.5	0	6.0
+6	0.35	0.09	−1.0	0	6.0
+9	0.35	0.12	−0.5	0	6.0
C−3	−0.12	0	−2.5	1.0	7.0
C	−0.32	0	−2.5	1.0	7.0
D	−0.3	0	−2.0	1.0	7.0
D+3	−0.25	0	−2.0	1.0	7.0
+6	−0.25	0	−2.5	1.0	7.0
+9	−0.25	0	−3.5	1.0	7.0

Table AVIII (Cont'd).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 13 (Max pitch 16°/sec, max roll 5.5°/sec, max yaw 4°/sec)					
Max	0.5	0.12	−7.5	2.0	8.0
A−3	−0.08	0	−1.0	−1.0	8.0
A	0	0	−1.0	−1.0	8.0
A+3	0.50	0.1	−1.0	−1.0	8.0
B	0.50	0.1	−1.0	−1.0	8.0
B+3	0.30	0.1	−0.5	−0.5	8.0
+6	0.25	0.1	0	−0.5	8.0
+9	0	0.1	0.5	−0.5	8.0
C−3	−0.12	−0.06	−2.0	2.0	8.0
C	−0.14	−0.06	−2.0	2.0	8.0
D	−0.15	−0.06	−2.0	2.0	8.0
D+3	−0.23	−0.06	−2.0	2.0	8.0
+6	−0.26	−0.06	−3.0	2.0	8.0
+9	0	−0.06	−4.0	2.0	8.0
Run 14 (Max pitch 12°/sec, max roll 9°/sec, max yaw 3°/sec)					
Max	0.61	0.12	−7.5	−3.5	10.0
A−3	0	0	−2.0	0	8.0
A	−0.08	0	−2.0	0.5	8.0
A+3	0.06	0	−2.0	0.5	8.0
B	0.16	0	−1.5	0.5	8.0
B+3	0.61	0	−1.0	0.5	8.0
+6	0.20	0	0	0.5	8.0
+9	0	0	1.0	0	8.0
C−3	−0.3	0.06	−2.0	1.5	10.0
C	−0.29	0.06	−2.0	1.5	10.0
D	−0.29	0.06	−3.0	1.5	10.0
D+3	0	0	−4.0	1.5	10.0
+6	0.35	−0.06	−5.0	2.0	10.0
+9	0	0	−6.0	2.0	10.0
Run 15 (Max pitch 12.5°/sec, max roll 5.5°/sec, max yaw 5°/sec)					
Max	0.63	0.3	−7.5	−2.5	15.0
A−3	−0.19	0	−2.5	−1.0	10.0
A	−0.12	0	−2.0	−1.0	10.0
A+3	0.10	0	−2.0	−1.0	10.0
B	0.32	0	−2.0	−1.0	10.0
B+3	0.63	0	−1.5	−0.5	10.0
+6	0.32	0.3	−1.0	−0.5	10.0
+9	0.04	0.12	0	−0.5	10.0
C−3	−0.44	0.08	−3.0	1.0	14.0
C	−0.44	0.08	−2.5	1.5	14.0
D	−0.43	0.08	−2.5	1.5	14.0
D+3	−0.18	0.08	−3.0	2.0	14.0
+6	0	0.04	−3.5	2.0	14.0
+9	0.10	0	−4.5	2.0	14.0
Run 16 (Max pitch 15°/sec, max roll 7°/sec, max yaw 4°/sec)					
Max	0.63	0.28	−7.5	2.5	8.0
A−3	0	0	−1.5	−1.5	8.0
A	−0.2	0	−1.5	−1.0	8.0
A+3	0	0	−1.5	−1.5	8.0
B	0.22	0	−1.0	0	8.0
B+3	0.28	0.28	−1.0	0	8.0
+6	0.25	0.16	−0.5	0	8.0
+9	0.15	0	0	0	8.0
C−3	0.35	0.12	−2.0	2.5	8.0
C	0.35	0.12	−2.0	2.5	8.0
D	0.35	0.12	−2.0	2.5	8.0
D+3	0.35	0.12	−2.0	2.5	8.0
+6	0.35	0.12	−2.5	2.5	8.0
+9	0.35	0.12	−3.0	2.5	8.0

Table AVIII (Cont'd). Dynamic response data, obstacle 4, 15 June 1971 (see Fig. 31).

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 17 (Max pitch 13°/sec, max roll 9.5°/sec, max yaw 8°/sec)					
Max	−0.45	0.12	−7.0	4.5	31.0
A−3	0	0	−1.0	1.0	13.0
A	0	0	−1.0	1.0	15.0
A+3	0	0	−0.5	1.0	17.0
B	0	0	−0.5	1.0	19.0
B+3	0.12	0.07	0	1.0	21.0
+6	0	0.12	0	1.0	23.0
+9	0	0.03	0.5	1.0	24.0
C−3	−0.45	0.06	0.5	0	31.0
C	−0.34	0.06	0	0	31.0
D	−0.14	0.06	−1.5	−0.5	31.0
D+3	0.40	0	−4.0	−0.5	31.0
+6	0.05	0.08	−5.5	−1.0	31.0
+9	0	0.08	−6.5	−1.0	31.0
Run 18 (Max pitch 15°/sec, max roll 5.5°/sec, max yaw 8°/sec)					
Max	−0.45	0.15	−8.0	3.0	18.0
A−3	0	0	−0.15	0.5	17.0
A	0	0	−0.15	0	17.0
A+3	0	0	−0.1	1.0	17.0
B	0.15	0	−0.5	1.5	17.0
B+3	0.11	0.15	0	1.0	17.0
+6	0.11	0.08	−0.5	1.0	17.0
+9	−0.10	0.08	−1.5	0	17.0
C−3	−0.34	0.10	1.0	2.5	18.0
C	−0.14	0	−2.0	3.0	18.0
D	0.21	0	−3.0	3.0	18.0
D+3	0.34	0.03	−5.0	3.0	18.0
+6	0.10	0.08	−7.0	3.0	18.0
+9	0	0.08	−8.0	3.0	18.0

Posn	Heave (g) + = up	Surge (g) + = ahead	Pitch (deg) + = bow up	Roll (deg) + = stbd	Yaw (deg) + = east
Run 19 (Max pitch 24°/sec, max roll 10°/sec, max yaw 2°/sec)					
Max	−0.46	—	−8.0	3.5	2.0
A−3	0	0	−1.5	1.0	0
A	0	0	−1.0	1.5	0
A+3	0	0	−0.5	1.5	0
B	0.2	0.05	0	1.5	0
B+3	0.05	0.18	0.5	1.0	1.0
+6	0	0.05	1.0	0	1.0
+9	−0.2	0.05	−1.5	−1.0	1.0
C−3	−0.46	0.06	1.5	1.5	0
C	−0.31	0.07	0	2.0	0
D	0	0.06	−2.0	3.0	0
D+3	0.38	0	−4.0	3.5	0
+6	0	0.06	−6.5	3.5	−1.0
+9	0	0.05	−8.0	3.0	−1.0
Run 20 (Max pitch 15°/sec, max roll 4°/sec, max yaw 7°/sec)					
Max	−0.35	0.2	−7.5	2.5	20.0
A−3	0	0	−1.0	2.0	20.0
A	0	0	−0.5	2.0	20.0
A+3	0.08	0.08	−0.5	2.0	20.0
B	0	0.20	0	1.5	20.0
B+3	0.10	0	0.5	1.0	20.0
+6	−0.13	0.20	1.5	0.5	20.0
+9	0	0	2.0	0	20.0
C−3	−0.25	0	2.0	0	20.0
C	−0.05	0	2.0	0	20.0
D	0.12	0	2.0	0	20.0
D+3	0.12	0	2.0	0	20.0
+6	0.05	0	2.0	0	20.0
+9	0	0	2.0	0	20.0